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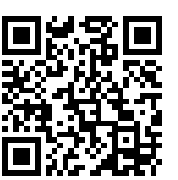

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The Royal Engineers Journal.

VOLUME XL.

1926.

QUARTERLY SERIES.

(MARCH, JUNE, SEPTEMBER, DECEMBER.)

CHATHAM:
THE INSTITUTION OF ROYAL ENGINEERS.

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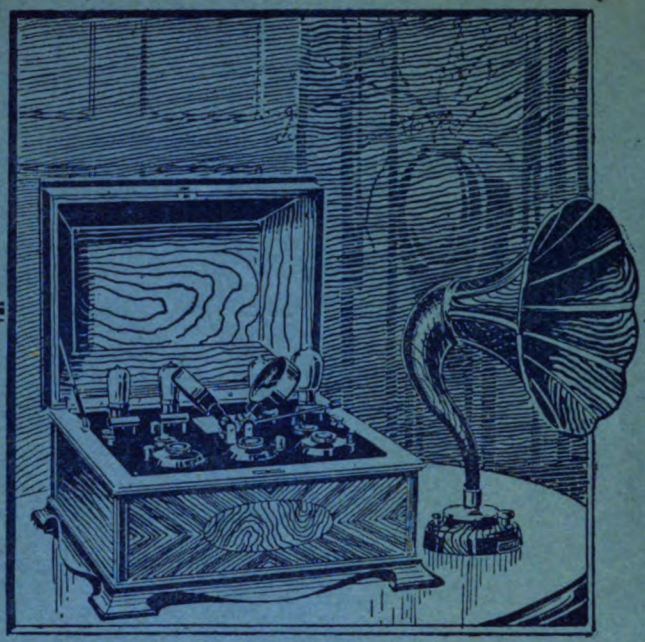

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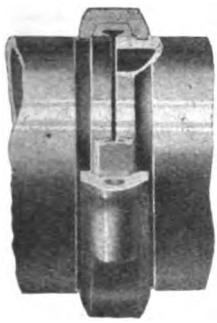

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COOPER'S HILL WAR MEMORIAL PRIZE ESSAY.

THE second of the triennial prizes presented to the Corps by the Cooper's Hill Memorial Fund is for competition during the year 1926, and the Council of the Institution of Royal Engineers has chosen the following subject :—

"The effect of mechanicalization of the Army on the organization and employment of Divisional and Corps Engineers in the Field."

Essays must reach the office of the Secretary, Institution of Royal Engineers, not later than the forenoon of the 1st September, 1926. Essays must not be signed, but each must bear a pseudonym and the name of the writer enclosed in a sealed envelope must be attached.

The Cooper's Hill Memorial Prize is a bronze medal, a parchment certificate, and a sum of money, about £20.

(*a*) *Qualifications of the Competitors.*—To be a regular officer of the Royal Engineers under the age of 35 on the 1st January of the year in which the award is made.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the Council of the Institution of Royal Engineers in the manner considered best for the encouragement of contributions on professional subjects, by R.E. officers, to the Corps publications. From the beginning of 1920 it was decided that the Prize should be offered to officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

(*a*) Descriptions of works actually carried out in peace or war.
(*b*) Inventions.
(*c*) Design (excluding works of defence).
(*d*) Labour organization on work.
(*e*) Scientific investigations generally.
(*f*) Accounts of exploration work and surveys.

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ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

Subject selected :—"Survey on Active Service."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2 :—

(a) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary? What projection would you employ and what steps would be taken to begin Survey operations?

(b) Do you consider the resources of the Field Survey Company adequate in personnel and stores to undertake the programme you have outlined? If not, what additional personnel, stores and equipment do you consider necessary? What reply would you make to the offer of the Colonial Survey given in paragraph 7? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make?

2. The Force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of Non-Divisional and L. of C. Units. These include 1 Field Survey Company plus Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foot-hills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and are all unmetalled except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ½-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section armed with revolvers and issued with pantaloons may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the Text Book of Topographical Surveying.

3. The printing machinery includes 1 double demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

Essays must reach the office of the Secretary, Institution of R.E., not later than the 30th November, 1926. Essays must not be signed, but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with a similar pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

1. The prize, which will take the form of a piece of plate, to be chosen by the the recipient, was instituted by Mrs. Garrett in memory of her late husband, Major Arthur ffolliott Garrett, O.B.E., R.E.

2. Qualifications of the recipient : To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1926.

3. The essay must not exceed 6,000 words.

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THE CONSTRUCTION OF THE TAL (TOCHI) BRIDGE.

COMPILED FROM THE REPORTS OF OFFICERS WHO TOOK PART IN THE WORK.

1. HISTORY.

A PREVIOUS article* describing the Isha-Razmak Road made mention of the fact that the bridging of the River Tochi was to be considered further when the road had been completed and Razmak occupied. The bridge, in fact, was allowed for in the original grant of 65 lacs of rupees, made for the road, but no work was done on the bridge until it was certain that the funds available were sufficient to complete the road, and until the real necessity for the bridge became clear. By January 1923, there were no doubts on the score of necessity, and funds remained.

Like other Indian frontier rivers which depend for their main flow on melted snow, the Tochi comes down in practically continuous spate from mid-March to mid-April annually. The volume of snow water coming down daily varies with the hours of sunshine, and is never, as a general rule, as heavy as the short, sharp, but very violent spates of a few hours' duration experienced in July and August.

The 700-ft. causeway, which had so far carried traffic over the Tochi River bed, had not failed under either spring or summer spate, but on a width as great as this it was impassable for a week at a time for lorries in the spring, whilst, in either spate season, heavy shoals of silt were deposited on it when the spates subsided.

The causeway, then, had fulfilled its purpose within its limitations whilst the policy regarding Razmak was still plastic, but with the decision to occupy Razmak permanently, and with visions of a new Quetta, a permanent high-level bridge became necessary to ensure that the line of communication should be open continuously.

2. SELECTION OF THE SITE.

At intervals along the length of the Tochi River there are bottlenecks formed by the rock outcropping and damming up the water and silt upstream.

*The Isha-Razmak Road—*R.E. Journal*, September, 1925.

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At Boya, and along the Kajuri-Saidgi length, such bottle necks have formed, upstream of themselves, the comparatively fertile "*kach*"* land plains of Mahomed Khel and Kajuri respectively.

In all previous proposed or completed bridging operations over the river it has been possible to find the bridge site at a bottle-neck. In the present instance, however, there was no bottle-neck suitable within five miles east or west, and consequently the selection of the bridge site became a matter of making the best of a broad winding river bed, with stretches of alluvial ground at the inside of every curve. Three sites were found to be worthy of consideration, and they are shown as A, B, and C on the accompanying site plan.

Site A offered an outcrop of rock in mid-stream, and the chance of getting the pier foundations on rock to the south of the outcrop, but it also entailed crossing the Tal Algad. Site C gave a blind north bank approach on to the bridge. Finally, Site B, which had been noted when the road alignment was decided, was selected.

This site had several advantages whilst being far from ideal. The north abutment was on solid rock. The set of the stream appeared to be constantly against the rocky north bank. The approaches were easier and cheaper than elsewhere. A stone quarry was close at hand; and, finally, Tal Fort, already built and occupied, overlooked the site.

The large area of low lying *kach* land which so considerably reduces the river bed width at site B was originally considered so liable to erosion, that it was intended to bridge this up to the old river bank, which is some 15 or 20 feet above bed level. However, fear of erosion was considerably lessened as a result of the construction, in early 1923, of a bell *bund*, which silted up a large area and formed shoals upstream which diverted the water to the north bank and consolidated the *kach* land. The next proposal was to bridge some 100-ft. only of the *kach* land, and to make a training groyne south of, and reinforcing, the bell *bund*. Finally, however, the local opinion was accepted that the bell *bund*, together with the additional protection afforded by the old road embankment from the causeway, would be sufficient to protect a south abutment sited on the river edge of the *kach* land.

This left a gap of some 800-ft. to be bridged.

3. DESIGN.

Since 1915 the railway companies in India have been strengthening all their bridges to meet the demands of heavier locomotives and rolling stock. In consequence, a large number of steel girders of the old, and lighter, design, have become surplus, and the North

* KACH—Cultivated alluvial soil.

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Western Railway has been disposing of them, suitably remodelled, for use on frontier roads. The Bridge Engineer of the N.W. Railway supplied six 110-ft. deck spans for this bridge at a price of £5 per ton at Jhelum. He also very kindly agreed to undertake their erection unofficially, which greatly simplified matters. The erecting gang was taken on to the pay sheets of the work, and all stores and plant were charged direct to the work, plant being bought back by the railway company on completion at the price paid less depreciation.

The piers and abutments had to be designed for erection largely by unskilled labour.

The shape of the piers, which is shown in the plate, is that found best for shingle nullahs, and is the result of considerable investigation in the Kohat district. It is found that so shaped, the piers induce a silt deposit at each end. They were also made thicker than usual, to withstand the ever-changing direction of flow of the streams which make up the river, and, since it might not always be possible during their erection to have continuous officer supervision, it was thought that the extra sturdiness of design would conteract the streaks of poor work which creep in.

Each pier was on a foundation of P.C.concrete, 1 : 2 : 4 reinforced with rails; above this, and up to the calculated scour level, a ring of stone in cement mortar enclosed mass concrete of the proportions 1 : 3 : 6, with 30 per cent. "plums." Continuing up to highest flood level was hammer-dressed stone in cement mortar. Economy called for H.D. stone in lime above this level up to the holding-down bolts, above which all work was in cement mortar.

The only certain method of determining the depth of scour in any river bed is to dig down to it. For estimating purposes it is useful to arrive at a basic figure from calculation. The figures given below are from memory, but they are sufficiently accurate to illustrate the method. Three cross sections of the river bed were surveyed and plotted, one on the bridge line and the others respectively a mile up and one mile down stream of the bridge line. By noting the highest flood level at each section the wetted area for each was computed. From a longitudinal section of the two miles of river bed in question, the slope of the river bed was determined.

These surveys gave :—

The mean of the three wetted areas (A), which differed less than 15 per cent. from the centre area	=2800 sq. ft.
The mean hydraulic depth (r)	= 4 ft.
The slope of the river (s)	= 0.02

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The velocity of the stream is given by Manning's formula—

$$V=\frac{1.486}{n}\times r\times s^{\frac{1}{2}}$$

(where n varies from 0.02 to 0.05.)

$$V=\frac{1.486}{.035}\times 4\times .02^{\frac{1}{2}}=15.3 \text{ ft. secs.}$$

The discharge of the stream is given by

$$Q=A\times V=42{,}400 \text{ cu. secs.}$$

Adding 33 per cent. 14,100

Whence Q^1 $=56{,}500$ cu. secs.

Trying a new value of r to suit Q^1—say $r=4.8$ft.—we have :—

$$V^1=\frac{1.486}{.035}\times 4.8\times .02^{\frac{1}{2}}=17.2\text{-ft. secs.}$$

A^1 (which is obtained from the cross section)$=3{,}320$ sq. ft.

So that $Q^1=A^1V^1=3{,}320\times 17.2$

$=57{,}000$ cu. secs.

which is sufficiently near to the value of Q^1 found before.

The afflux h is given by :—

$$h=\left\{\frac{(V^1)^2}{58.6}+.05\right\}\left\{\left(\frac{A^1}{a}\right)^2-1\right\}$$

For a allow a 10 per cent. reduction of area on account of the piers. Then $a=.9A$.

$$h=\left\{\frac{17.2^2}{58.6}+.05\right\}\left\{\left(\frac{10}{9}\right)^2-1\right\}=1.18 \text{ ft.}$$

The average depth at the bridge before scour is therefore—

$$d=4.8+1.18=6 \text{ ft.}$$

This figure agreed with the highest flood level found by observation.

The velocity under the bridge is given by :—

$$V_2=1.1\times\frac{A^1}{a}\times V^1$$

$$=1.1\times\frac{10}{9}\times 17.2=21 \text{ ft. secs.}$$

The depth of scour (d^1) is found firstly from Kennedy's formula—

$$V_3=.84\, kd^{.64},$$

which gives V_3, the critical velocity just not sufficient to cause further scour; secondly, by assuming that the discharge after scour is the same as before it, namely that :—

$$dV^2=d^1V_3$$

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k varies from 2 to 3. For coarse gravel and boulders, as in this case, say 2.5.

Then

$$d^1 = \frac{dV_s}{V_s} = \frac{6 \times 21}{2.1 \times 6^{64}} = 19\text{-ft.}$$

The depth of scour is therefore 19-6=13 ft. below bed level. As a result of excavation the greatest scour depth was found to be 11½-ft. Previous experience on Frontier streams has shown that it is safest to double this figure for the depth of the foundations, since these bridges are subjected to conditions for which the formulae make no allowance whatsoever.

The estimate, which was completed by the end of February 1923, totalled 7.98 lacs of rupees, or £53,210 nominal.

4. Preliminary Work.

A somewhat premature start on the actual construction was ordered in mid-April, 1923. Although on the Kabul River, October is probably the best time to start such a project, in order to complete the work in 12 months, it was very advantageous on the Tochi to make use of the three-and-a-half months between the spring and summer spates, since during these months work is possible throughout the whole 24 hours. After October it is too cold for more than a short day's work, and no night work is possible.

When work commenced on May 14th there were a bare ten weeks available before the summer spates, and consequently the original programme of three piers and one abutment, commencing from the north bank, all built up to mean bed level, had to be reduced to two piers and one abutment. Preliminary work consisted in:—

(*a*) Putting out the work on contract.
(*b*) Collecting materials.
(*c*) Collecting tools and plant.
(*d*) Laying out the work.
(*e*) The construction of protective and guide dams upstream.

A few notes on each will explain these.

(*a*) The work was taken by the best of the Isha-Razmak Road contractors at 5 per cent. below Razmak rates, with a special rate of Rs. 250 per 1,000 cu. ft. for excavation below 6 ft. depth, and an allowance for "protection." The cost of bringing up labour and rations was borne by the contractor. This contractor was a real backwoodsman, and conservative to the last degree, which is exemplified by his refusal to touch the work if a specially procured mechanical grab was used.

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As is customary on such jobs, much money was saved by refusing the high tenders and superior organization and methods of the down country contractors, and a corresponding amount of *dikh*, obstinacy, mulishness, and claims was incurred when the local tender was accepted.

(*b*) The collection of materials commenced in April, 1923.

An excellent quarry of flat-bedded limestone, only a mile from the site, furnished masonry stones of almost any size required.

Shingle for aggregate up to 1½-in. was in the river bed in unlimited quantity. This, although comparatively clean, was all washed by being shovelled on iron sheets through a shallow stream of the river.

Lime was obtained from river boulders, burnt near by, and proved slightly hydraulic.

Mortar, of proportions 1 brick dust, 2 sand, 5 lime, was ground by a stone in a circular stone trough, and was stored under water.

Cement of Indian manufacture was used throughout.

At first a grading machine was used for the shingle, but it was found that the natural mixture of the river bed could not be improved upon.

(*c*) The estimate allowed Rs. 20,000 for tools and plant. This sum was quite inadequate to provide plant to enable the work to be completed at the rate at which it was intended, and commitments under this head at one time amounted to one lac. Consequently it became necessary to use this sum to cover the cost of depreciation of the plant only, and to arrange concurrently for the disposal of the plant immediately it was no longer required on the work.

Previous experience on similar work had shown the necessity for one 8 to 9-in. centrifugal pump per pier excavation. The requirements were, therefore, four 9-in. centrifrugals, allowing one spare, three portable engines, three concrete mixers, tackles and derricks for moving pumps, timber for shoring, and the usual digging tools and appliances.

These were collected from far and near, Kohat, Peshawar, Pindi, the Engineer Park at Lahore, and the N.W. Railway all assisting.

(*d*) The work was laid out as described below, and marked with small masonry pillars, cement rendered. The north bank abutment was in this case first located, and the centre line of the bridge marked by two pillars erected beyond each end of the bridge.

Further pillars were then built on this line, one at the actual centre point of each pier. Two pillars were erected respectively sixty feet on the up and down stream side of each pier centre pillar, so that the line joining them passed through the centre pillar and was at right angles to the centre line of the bridge.

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This allowed of the quick replacement of any pillar destroyed or removed by any cause.

Finally, when excavation commenced, two subsidiary pillars per pier were erected, respectively 30 ft. short and beyond the pier centre pillar, and on the centre line of the bridge.

The pier centre pillar was then removed. These pillars were all laid out with the theodolite and their levels, referred to a bench mark on the north bank, accurately determined.

(*e*) Temporary dams had been necessary to complete the causeway, and these had all directed the flow of water towards the north bank.

During the spring spate of 1923 the driver of a new M.E.S. 4-ton Packard lorry tried to drive across the causeway when some 2 ft. of water was flowing over it. Unfortunately, instead of watching the opposite bank, he became mesmerised by the flow of the stream across his front, until finally he could resist it no longer and proceeded to follow the direction of flow with his lorry. This occurred close to the north bank, and in order to retrieve the lorry all the dams had to be altered round to divert water to the south bank, and the plan of operations was therefore changed, so that construction was carried out from north to south.

The dams were originally in three lines across the river bed.

The first line, furthest from the bridge site and some three-quarters of a mile upstream, was designed to withstand and divert the spates. It consisted of shingle banked 8 ft. high and 15 ft. wide at the base, faced upstream with boulders in wire crates 18 in. thick, and with a toe wall, 4 ft. wide, in the same construction. At points liable to special exposure the dam was built entirely of boulders in crates.

The two lower lines were intended to deal with surface water, but the upper one was faced with boulders in crates. Owing to a spate, the direction of which was inclined at 45° to the normal line of flow of the river, a fourth dam was necessitated running down the centre line of the river from the uppermost dam to a point on the causeway.

Pier excavations Nos. 1 and 2 were ringed round with walls of shingle in sandbags as an additional precaution.

5. Excavation for Piers and Abutments.

It has been explained that, owing to the antipathy of the contractor to modern methods, the whole of the excavated spoil on each pier was removed by a swarm of coolies using iron baskets.

Work proceeded on these lines comparatively quickly down to a depth of 6 ft., or so long as the coolies could run out of the excavation. Below this depth, and after the shoring had been com-

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menced, the soul-shattering spectacle was witnessed of coolies sitting on struts and ladders handing the baskets up to one another.

Even the thin grass rope and *chattie* and windlass, so dear to the heart of the native well-sinker, was taboo.

The depth of the excavation for No. 1 pier was such that the 8 in. centrifugal pump, which it was intended to use eventually, could not be set in its final position for efficient working until excavation had proceeded down some ten or eleven feet.

Down to this depth the water was dealt with by a 4 in. centrifugal pump driven by a 2-cylinder Aster engine.

The 8 in. centrifugal was located in a wide 6 ft. trench cut off from the main excavation, and it was actually bedded on a sleeper cribwork and connected by belt drive to a portable engine above in the river bed.

Two standing derricks with differential tackles were provided, and so placed that one could take the weight of the cast iron suction pipe and foot valve, whilst the other was available to raise or lower the pump as might be necessary in order to fit in a further length of suction pipe—adjustment being made by altering the amount of crib piering under the pump.

This arrangement gave considerable trouble, owing to the difficulty of maintaining a correct alignment between the pump and the engine to ensure the belt remaining on the pulleys.

Further, the use of heavy cast-iron suction pipe, suspended in the air, resulted in constant air leaks at the joints.

The second of these difficulties was obviated, when the excavation of No. 2 pier was commenced, by the use of light sheet-iron suction piping of local (railway) manufacture, and by placing the pump directly over the sump, supported on two baulks, the ends of which were carried, on one side in the cut or trench, and on the other on the moveable transom of a 2-legged trestle.

The trouble with belt alignment continued, and no really satisfactory arrangement was devised until electric drive was installed, as will be described later.

In all the excavations the sumps were arranged at the down stream ends, although, in order to save them, in case of failure of a dam under a sudden spate, the portable engines were on the upstream side. It was found that the inflowing water caused such falls of earth and shingle, that a sump at the upstream end would result in the footvalve being constantly buried.

The work of excavation is all dependent on the water being kept down by the pump, and a most frequent source of temporary stoppage is choking of the footvalve, due to the sump being neglected.

The bottom of the sump must be kept 2 ft. below the level of the main excavation, and the footvalve must not get within 6 in. of the bottom of the sump.

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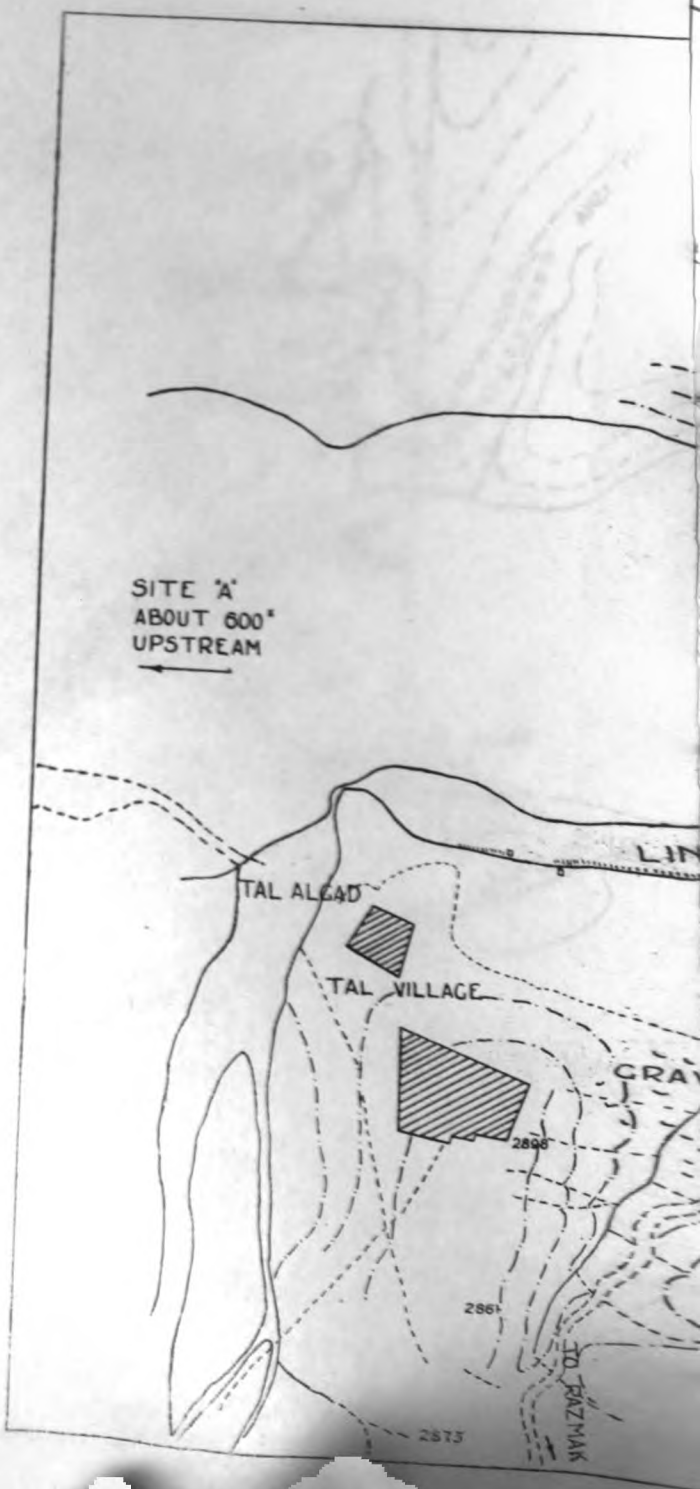

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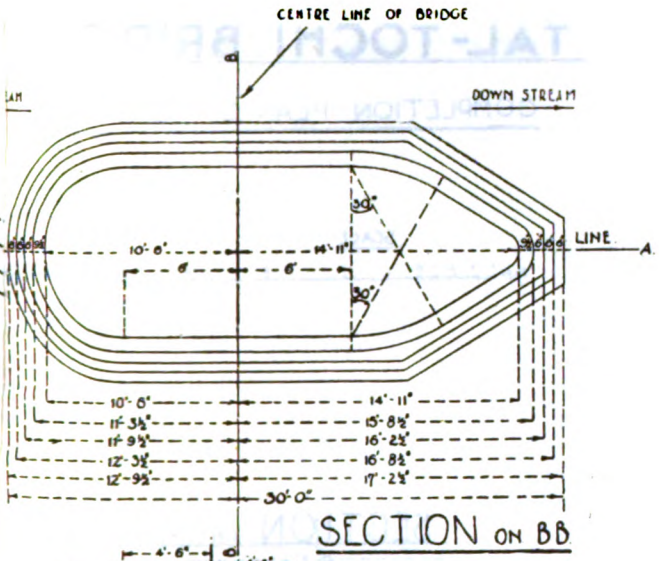
PLAN.



SECTION ON BB

TYPE OF SOIL IN EXCAVATION

1. FROM RIVER BED TO R.L. 111.3
   SHINGLE & BIG BOULDERS HARD PACKED
2. FROM R.L. 111.3 TO 109.3
   RED CLAY & SHINGLE HARD PACKED
3. FROM R.L. 109.3 TO 104.3
   BLACK CLAY HARD WITH OCCASIONAL BOULDERS

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1. Early work on No. 2 Pier excavation.

2. No. 2 Pier showing shoring and over bridge.

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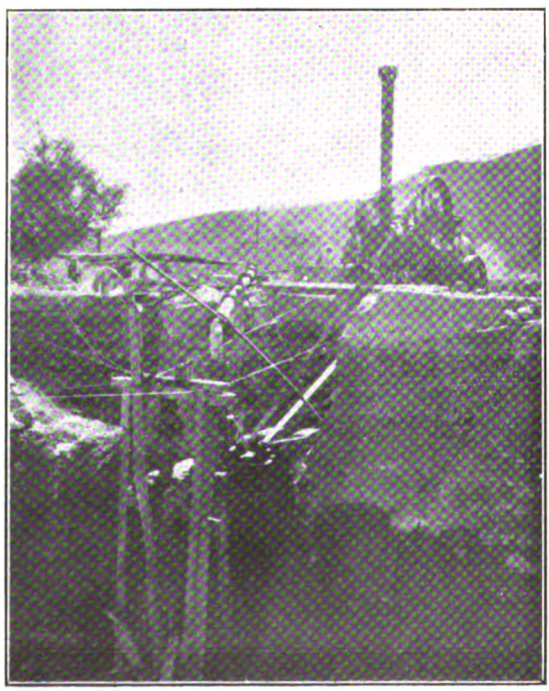
3. No 2. Pier built up to mean bed level.



4. Pumping arrangements on South Bank abutment.

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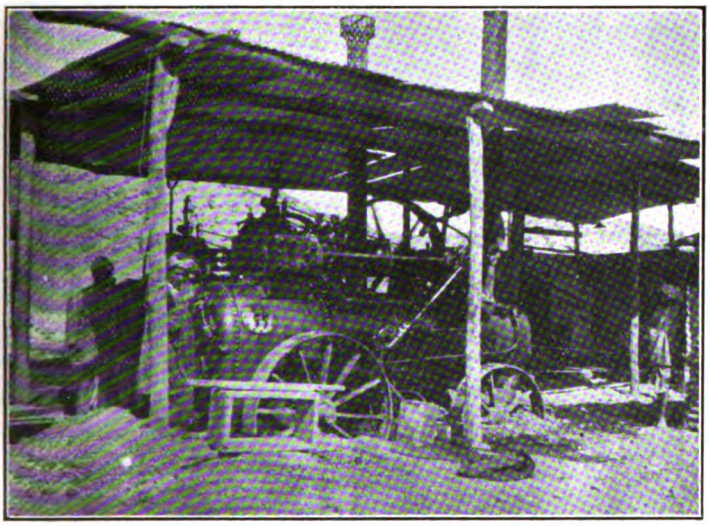
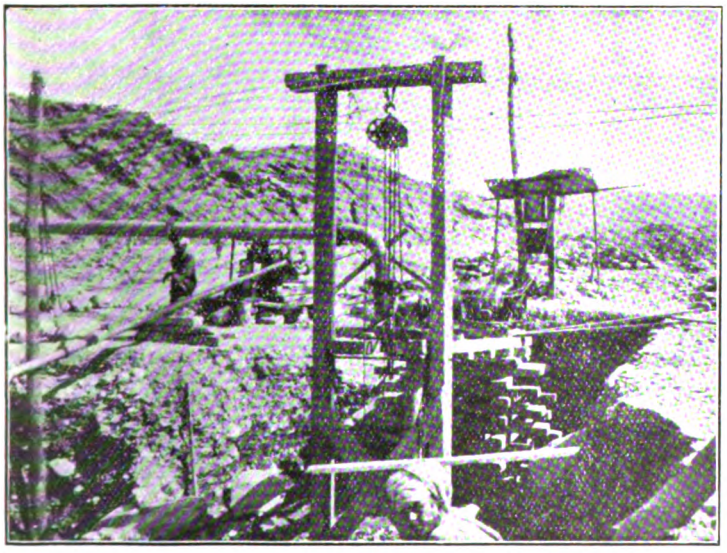


5. The Power House.



6. No. 5 Pier pumping arrangements.

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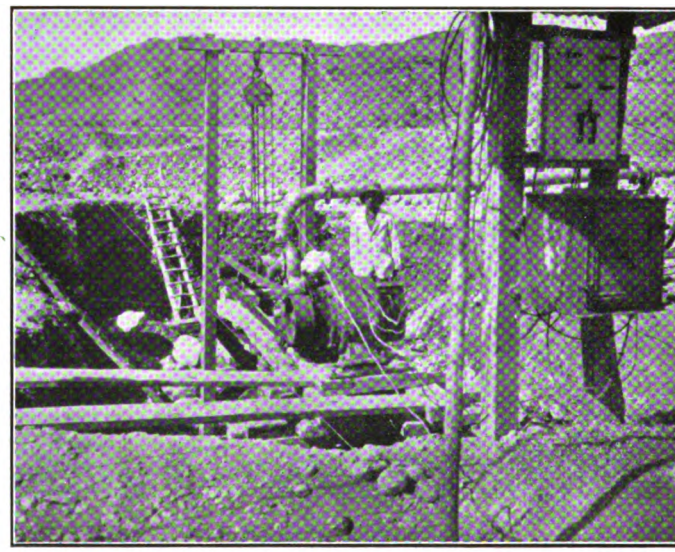
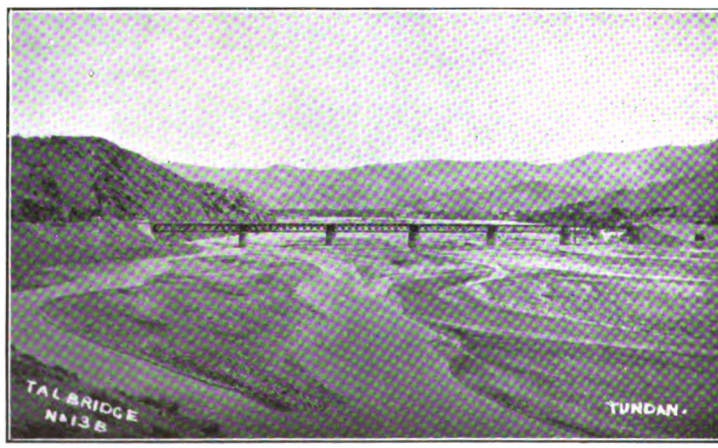


7. **No. 5 Pier showin electric drive to pump.**



8. **The Tal Bridge complete, seen from the West.**

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In such work, the footvalve requires additional protection, and is best enclosed in a bag of wire gauze, tied tightly round the strainer.

A small portable petrol-driven pump, mounted on one bedplate, was kept by, as an emergency measure, for use when a temporary stoppage occurred on the main pump. A set of this nature was found to be invaluable, since it could deal with all water met with up to 18 ft. depth, and was also of great use in starting excavations.

Shoring was found necessary at a depth of 6 ft., when the excavation began to fall in badly, and it was carried down to a depth of 12 to 15 ft., when solid clay, with large boulders embedded in it, was met.

The shoring consisted of 2 in. planks driven down outside a horizontal frame supported by cross struts; the frame and struts being of 12 in. by 6 in. timber, all dogged together.

As the excavation progressed the planks were slightly undercut, and the whole structure of frame and planking was easily driven down. The excavations for the north bank abutment and Nos. 1 and 2 piers took some five weeks, which included all the time lost in failures of the plant, and a whole week on account of a spate. Work was speeded up by working night shifts, and by the provision of bridges over the excavation, which provided additional roads for the removal of spoil.

The night shifts were originally lit by Kitson lamps, which proved expensive owing to the frequent breakage of the glasses. The two Pelapone electric light sets, which eventually replaced them, were very much better and cheaper.

Throughout this work there was the customary continual strife with the contractor, mainly over the standard of unwatering. He was, therefore, made to agree to no claim for stoppages under half-an-hour, due to a depth of water of over 6 ins., or cases of major breakdowns, where he had been given due warning and could switch his labour on to approach roads. A log was kept on the job which showed all stoppages, and was signed by the contractor daily.

The completed excavation, which was made 2 ft. larger all round than the masonry work, was checked for size, alignment, and level, and was then dried out before the concrete foundation was put in. The only satisfactory method of stopping all the small springs, by which the water leaks in from the sides and bottom, was found to be to build a 3 ft.-high wall of dry concrete mixture in sandbags, outside the area for the foundation, and to excavate over the floor an additional 6 ins., and carefully lay this with bags of the same mixture.

6. Pier Construction.

The foundation was laid out, and the work checked as it proceeded by a theodolite mounted on the over-bridges mentioned previously.

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The piers were checked at every offset up to bed level.

All concrete was mixed in a mechanical mixer at bed level, and was shot on to the work down a wooden trough, and laid in 6-in. layers.

For a brief spell a petrol driven mixer did most efficient work, but, like so many other mechanical contrivances, it had not been designed for work in the East. It was not long before the cry of "*Sahib phutgaya*" announced that it had passed on, like many another unsuspecting piece of mechanism.

The work of concrete laying proceeded rapidly. The outer stone ring was given a very rough finish on its inner side and was built up in 3 ft. stages, as the concrete laying progressed. During the laying of the concrete, the masons worked on the laying and proper bedding in of the stone "plums." Above the level of calculated scour, where the pier was of solid masonry, the method for each course was first to lay the outer ring, next to lay, in cement, two transverse, and one longitudinal, lines of flat stones, hammer-dressed on four sides. In each succeeding course these lines were staggered.

In any one course the spaces between these three lines were filled with what may be termed "horizontal random ashlar work," that is, very irregular, un-dressed stone, carefully keyed, so as to leave no gap greater than 2 ins. These gaps were first filled with mortar, after which stone spawls were driven tightly into them.

As in other forms of masonry, the great difficulty was to get the masons to lay each stone with mortar, their preference being to lay several stones and then merely to grout around.

The commencement of the summer spate season saw the masonry of the north bank abutment and Nos. 1 and 2 piers completed up to mean bed level, and during the ensuing two months work was confined to building these up, and to work on the north bank approach road.

7. EMPLOYMENT OF ELECTRICALLY DRIVEN PUMPS.

Had the work on piers 1 and 2 been further advanced it would have been politic to change round the dams just before the summer spates began, about August 1st, and commence work on the south bank abutment then. But, owing to the large amount of stone collected around these two northern piers, which would have been washed away, the dams could not be altered until the end of August, by which time the spates had carved deep channels in the river bed, making the work more difficult.

It was found possible to commence the excavation of the south bank abutment at the beginning of September, but the remaining piers could not be safely tackled until the end of that month, by

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which date it was expected that the spates would be over for the year.

In view of the trouble experienced on the first two piers, Simpson, the E. and M. Officer, got out a scheme for driving the pumps on the remaining four excavations by electric motors supplied by current from a temporary central power station to be put up on the bank.

The advantages were several, chief amongst them being :—

1. Reduction in working costs as a result of using fewer prime movers—in this case portable engines—and a reduction in the personnel required ;
2. Improved efficiency as a result of having spare engines—allowing for proper cleaning out—and improved control ;
3. Saving in time, since with pump and motor on the same bedplate there was no difficulty over belt alignment ;
4. Increased safety of prime movers, since the portable engines could be kept on the bank, and not in the river bed where a sudden spate might damage them.

The scheme was sanctioned and it was first put into operation on September 15th, two 15 k.w. generators and three 10 h.p. motors having been collected from Idak, Dardoni, Rawalpindi and Lahore.

The work on the south bank abutment was completed by the old method of a portable engine driving the pump, as the motor ordered for the new scheme did not arrive in time.

The power house, which was a rough shed of poles and corrugated iron, contained two portable engines dug down, each driving a 15 k.w. direct current generator on a concrete bed. A separate switch board, with overload circuit breakers, was erected for each generator. The current was carried from the power house to the distributing station by 37/16 insulated cable.

The distribution board carried a main D.P. switch and 200 amp. fuzes, and D.P. switches and fuzes for each of the three circuits supplied. Close to each of the three excavations—piers 3, 4 and 5—were the main switch, fuzes and starting rheostat for each motor.

An 8 in. centrifugal pump was assembled on an adjustable bedplate with a 10 h.p. motor, and pulleys were made up locally of wood, plated with $\frac{1}{4}$ in. mild steel plate, to give the correct driving ratio.

A similar set was provided for each of these three excavations.

Six-in. flexible suction hose had been ordered to obviate the necessity of adding lengths of suction pipe as the excavation progressed ; as, however, only one length had arrived when work commenced, it was only used on No. 5 pier.

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Flexible suction hose saves much time on a construction job like this so long as it is new, but once it becomes damaged and leaky, it is a snare and a delusion, and should be scrapped at once.

At the beginning of October, Pier No. 4 was commenced with the portable petrol pump, followed soon after by Pier No. 3, with an extemporised set consisting of a 3-in. centrifugal driven by a Pelapone engine. When both these excavations had been taken down sufficiently deep, the portable sets were replaced by the larger 10 h.p. motor-driven sets already prepared for them. The scheme proved most successful in operation, and when all three excavations were fixed up together, it was found that, by pumping from them in rotation, one portable engine could deal with the work, the second engine having steam up in case of a breakdown.

By December 10th, Piers 3, 4 and 5, and the south bank abutment, were all excavated and built up to mean bed level.

The number of days worked on these was approximately the same as those spent on the two piers and one abutment before the summer spates, but the number of hours worked only averaged 8½ per day as compared with the continuous shifts which were possible earlier in the year.

It is only fair to say, however, that much time was lost earlier in the year in breakdowns, while, in the second period, breakdowns were eliminated, as a result of the thorough overhaul of the plant during the summer spate season.

By December 27th, all masonry was complete up to the top belt of 1 : 2 : 4 P.C. concrete, which was laid by direct labour, and the contractor was diverted on to the approach roads on either bank, which work had hitherto been used only as a stop gap for his labour during spates or breakdowns.

8. Erection of the Girders.

The railway gang, which had rendered excellent service in shifting and adjusting heavy weights, besides semi-skilled work on shoring and sumps, commenced the erection of the girders on December 20th.

Each span arrived in five sections, each weighing five tons, for convenience in handling and haulage by road from the railhead at Bannu, some 35 miles distant. These pieces were riveted up in the river bed by a trained gang and hoisted on to the piers by a derrick at each end of the span, after which the holding down bolts were put in and grouted. The cross-bracing and corrugated mild steel troughing were completed in the intervals between the arrival of the girder sections.

The sections were hauled up the road from Bannu by six steam-rollers and a steam tractor, no other haulage being available.

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Notwithstanding a certain amount of delay in the arrival of the girder sections, the erecting gang had all the steel work completed by mid-April, 1924, when the supervisor, as a reward for this, and many other road bridges erected by him on Frontier M.T. roads since 1916, was very deservedly rewarded by the grant of the title of Khan Sahib.

9. Conclusion.

The approach roads had been completed in February, when the contractor was finally paid up, much to the relief of the staff, who were always busy keeping him up to his work and combating his innumerable fancied claims for losses. His achievement of five piers and two abutments completed in nine months must constitute a record for Frontier bridge work, and no small share is due to the S.D.O., Khan Sahib Miram Baksh, who worked splendidly throughout.

When the cement concrete roadway over the corrugated troughing had been laid, the bridge was opened to traffic in June, 1924, just over a year from the commencement of the work.

In spite of a good deal of unforeseen expenditure, much of which was due to breakdowns in the earlier period, the work was completed without an excess over the estimate.

The officers employed on the job, all of whom had a hard time, were Major L. C. B. Deed, D.S.O., in charge, Ross (on the early investigation and estimate), Stillingfleet (on construction up to the end of July, 1923), Fox (during August, 1923, and at the close of the work), Martin (during most of the autumn and winter), and, above all, Simpson, who was in charge of the E. and M. arrangements throughout.

In conclusion, it may be said that electric drive was clearly proved to be preferable from every point of view to portable engines with belt-driven pumps, and although oil engines would have been handier and more cheaply maintained for driving the generators, the capital expenditure entailed in their purchase was hardly justified with so many portable steam engines already available.

A small and efficient workshop was found to be essential to keep the plant in running order, whilst the advantage of the small, highly skilled railway gang, capable of dealing with heavy weights, was very great.

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THE ENGINEERS IN THE AUSTRALIAN MILITARY FORCES.

By C. H. F.

BEFORE commencing a description of the Engineers' organisation in this Commonwealth it must be explained that, as in Britain, there exist two distinct categories of troops—the Permanent Forces, and the Citizen Forces.

PERSONNEL.

The Permanent Forces are a small body, officered by Staff Corps Officers, and comprising the Australian Instructional Corps, Royal Australian Field Artillery, Royal Australian Garrison Artillery, Royal Australian Engineers, A.A.S.C., A.A.V.C. and A.A.M.C.

Enlistment in these Units is voluntary, the first period of enlistment being for five years, with subsequent terms of re-engagement for three-year periods.

The training is on lines similar to that of the corresponding units of the Regular Army in Britain.

The Citizen Forces are raised under Part XII of "The Defence Act, 1903-1918," which imposes the liability for military training on all male inhabitants of Australia between the ages of 12 and 26 years (excepting those exempted by the Act) who have resided there for six months and are British subjects.

Financial considerations have led to various modifications in the application of this liability, with the result that at present the service must be given for one year in the Senior Cadets and three in the Citizen Forces. The trainee therefore commences his Citizen Force service on the 1st July in the year in which he reaches the age of 18, the previous twelve months having been spent in the Senior Cadets.

Voluntary enlistment, within certain prescribed limits, is also permitted.

The training in the Senior Cadets is elementary, and includes no technical Engineering or Artillery subjects; it comprises merely musketry, marching, and physical training.

At the beginning of each financial year, i.e., on the 1st July, a "quota" becomes due for transfer from the Cadets to the Citizen Forces; on 1st July, 1926, for example, the "1908 Quota," composed of trainees born in the year 1908, will become due, while the "1905 Quota" will become due for transfer to the Unit Non-Effective List, and the "1909 Quota" will be mustered into the Senior Cadets.

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In so far as the technical arms—e.g., Artillery and Engineers—are concerned, Commanding Officers of Technical Units are authorised to select from the incoming Quota those who, by reason of their trade or other qualifications, are suitable for the unit.

For the Engineer Units, naturally, Commanding Officers select apprentices or young tradesmen of suitable trades, with the addition sometimes of a few clerks and one or two who are in the cooking trade or are willing to be trained as cooks.

Establishments.

Royal Australian Engineers.

The Establishment of Royal Australian Engineers is, necessarily, not large. It comprises merely sufficient Warrant and Non-Commissioned Officers and Sappers to maintain the Coast Defence Lights, and communications, and to form a nucleus manning detail thereof, to run the launches employed in the larger Coast Fortresses, and to provide technical storemen for Citizen Force Units.

From the R.A.E. also are found the Warrant Officer Instructors for Citizen Force Engineer Units, both Field and Fortress, and in a large degree those for Signal Units also. These, on promotion to Warrant Rank, are transferred to Australian Instructional Corps.

The Officers (except a small number in " Works ") are members of the Staff Corps.

The Establishment of R.A.E. for the current financial year is :—

Regimental	120	Warrant and N.C.O. and Sappers.
Works Section	19	" " " " "

In addition there are 15 Officers of the Staff Corps doing duty with R.A.E. or as Adjutants, etc., of Citizen Force Engineer and Signal Units, and several Warrant Officers A.I.C. Instructors to such Units.

Citizen Force Engineer Units.

The Citizen Forces of the Commonwealth are organized on a Divisional Basis, consisting of :—

2 Cavalry Divisions.
4 Infantry Divisions.
3 Mixed Brigades.
6 District Bases.

The latter comprise, *inter alia*, the Coast Defence Units raised in a District, of which there are six, corresponding, practically, with the six States of Queensland, New South Wales, Victoria, South Australia, West Australia and Tasmania.

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The organization of the Divisional Formations follows that of the British Army; the three Mixed Brigades together are equal to a complete Division, less a few details.

On the Divisional and Cavalry Divisional Organization, therefore, there are:—

5 H.Q. Divisional Engineers.
2 Field Squadrons.
4 Field Park Companies.
15 Field Companies.

It will be noted that no portion of a Fifth Field Park is raised in connection with any of the Mixed Brigades, each of which has merely the one Field Company allotted to it.

The Coast Defence Engineer Units comprise six Fortress Companies, one in each District, except 4th (South Australia), in which none exists, and 2nd (New South Wales) in which there are two.

The Training Establishment of Units is as follows:—

H.Q. Divisional Engineers:—

1 Commanding Officer.
1 Adjutant and Quartermaster (Staff Corps Officer).
1 Sergeant Major (Australian Instructional Corps).
1 Orderly Room Sergeant.
1 Farrier Sergeant.
3 Drivers.
1 Storeman (R.A.E.)

Each Field Company has an Establishment of 4 Officers and 80 other ranks, being composed of a Headquarters and 3 Platoons. The allotted transport consists of a Maltese cart and two water carts for each H.Q. with three carts, tool, three wagons, L.G.S., and three wagons G.S. per Company.

The two Field Squadrons with the Cavalry Divisions are each composed of a Headquarters and Headquarters Troop with three Brigade Troops, the total Establishment of a Squadron being six Officers and 53 other ranks. The allotted transport consists of three tool carts, a water cart, on G.S. wagon, and three L.G.S. wagons per Squadron.

The Training Establishment of each Field Park Company is 3 officers and 27 other ranks, with a small transport echelon sufficient for the conveyance of Bridging stores for training purposes.

The Fortress Companies are of divers establishments, according to the extent of the Fortress to which each is detailed, varying from an establishment of 1 officer, 10 other ranks, to one of 4 officers and 80 others; the total establishment for the six Companies is 15 officers and 200 other ranks.

The Establishments given above are those for 1924-25; it is probable that these will be considerably increased for the financial year 1925-26.

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Training.

The Training of the Permanent Forces, as far as the Royal Australian Engineers are concerned, is similar in many respects to that of the Royal Engineers except that there is no training in "Trades."

The small size of some of the detachments, however, means that in some stations the R.A.E. are employed throughout the year (except when the Citizen Force Units are in camp) on the maintenance of the E.L. plants.

On the larger stations it is practicable to carry out training in all phases of E.L. work, and in addition to give a certain amount of training in field works.

Schools and Courses of Instruction are carried out periodically for the instruction of Warrant and Non-Commissioned Officers and Senior Sappers of the R.A.E.

It should be mentioned that, in the Permanent Forces, Certificates of Education must be possessed by all ranks before promotion —i.e., 3rd Class for promotion to Corporal, 2nd Class for Sergeants, and 1st Class for Warrant rank.

The training of the Citizen Forces is made up, under the Regulations, of two natures :—

(*a*) Home Training.
(*b*) Camp Training.

Under present conditions, for the Engineers, Home Training must consist of four days, and Camp Training of eight days. The Home Training may be made up of "full days," "half days" or "night drills," in any proportions laid down by the Divisional Commander.

Camp Training must consist of Training in a Continuous Camp for the whole period of eight days.

These Camps are usually Brigade Camps; in the two larger Districts the Infantry Brigades of a Division follow one another on the same Camp site, with intervals of three or four days between Camps. The whole of the Divisional Engineers, as a rule, attend one of these Camps. In the other Districts a joint Engineer Camp may be held for both Field Companies and Field Troops.

The Fortress Engineers, of course, go to camp at their stations, at the same time as the Garrison Artillery Companies of the Citizen Forces.

In addition to the "Statutory" Camps and Home Training drills, all Engineer Units hold voluntary "week-end" Camps.

These sometimes take the form of a march, with transport, to some convenient place, a bivouac for two nights, and the performance of some work, such as bridging, water supply, reconnaissance, etc. Fortress Companies run the lights at their Station.

Perhaps it should be explained that, in Australia, almost all "Statutory" holidays are held on the Monday next after the

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actual date; for example, last year the King's Birthday Holiday was held on the 8th of June, although the Salutes were fired on the actual date.

This makes for several long "week-ends" from Saturday to Tuesday morning.

The actual instruction in Camps is carried out by the Officers and N.C.O. of the Units, the Permanent (A.I.C.) Instructor merely supervising or advising as a rule, except when some special work, or new work or drill requiring detail, is done.

Since practically all ranks of the Engineers are tradesmen of some kind, their instruction is not difficult. The Sappers are all very keen, and one never sees any symptoms of boredom or mental weariness among them. The writer speaks from some twenty-five years' association with the Corps when he says that to instruct them is a pleasure.

It is laid down in *Instructions for Training, Australian Military Forces*, 1925, that all practical work in the field will be based on a definite tactical scheme, and, furthermore, that "an endeavour must be made to carry out complete schemes . . . . . and the work will be arranged and materials provided to ensure this being done. If schemes are uncompleted Units do not see the result of their labours, and the training loses much of its value."

Near all the Camp sites in Australia there is ample ground for all classes of Engineer training. In Victoria, near the Seymour Camp (60 miles from Melbourne) runs the Goulburn River, a stream of diverse characteristics in every mile of its course. Within a mile or two of the Camp are broad lagoons, a wide river with a slow current, or a steep-banked stream running five knots.

On the George's River at Liverpool in New South Wales, there are good facilities for bridging, while around Brisbane (Queensland) there are many rivers—broad, narrow, swift, or sluggish, as desired.

For materials, additional to the Service gear, there is no lack of bush timber which may be had for the felling.

Field works can be carried out anywhere, and the bugbear of having to "fill-in" afterwards need not be feared—the Infantry love to use them next year in "attack" practice.

In conclusion, it may safely be said that the Field Troops and Companies in Australia have ample opportunity for thorough practical training, and that they have made good use of them.

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THE EARLY YEARS OF THE ORDNANCE SURVEY.

(*Continued.*)

IX. Progress of the Survey of Ireland from 1826 to 1839. Portlock, Reid, Larcom, O'Donovan.

Colby's System.—Colby often refers in his letters to his "system" of surveying, and as this system is the origin of the distinctive methods of the Ordnance Survey, it will be as well to describe it briefly. The main principle of Colby's system was that of division of labour; the all-round subordinate was not wanted in this system. Each man had a definite job to do and was kept at that. The surveyor who carried out the chaining did not plot his work; the plotting was given to other men. The man who plotted the main lines of the survey did not plot the detail. Afterwards, by an extension of the system, the surveyor who examined the work on the ground and inserted names and descriptions had nothing to do with the drawing or tracing. In the trigonometrical branch, in later years, the observers never computed their observations, but worked quite blindly as to the results of their work. There is much to be said for such a system; each man becomes very expert at his own particular speciality. It sounds, perhaps, a little dull for the surveyors; and, indeed, some men spent their working lives in doing the same thing over and over again. But it is less dull than it sounds, and if a surveyor in the field became incapacitated by illness, or from other causes, he could be brought into the office and trained up in another routine. The method is well suited to the large-scale survey of a civilized country; it would be quite unsuited to the topographical surveying of a tropical dependency.

Some copies have come down to us of the *Instructions for the Interior Survey of Ireland*, a small pamphlet of some 30 pages, "lithographed at the Ordnance Survey Office, Phœnix Park, Dublin," in 1827. The *Instructions* begin with the statement that, "The Interior Survey of Ireland is to be performed on a Scale of Six Inches to one English Mile; and the Plans are to be drawn with all the Accuracy and Minuteness of detail which that Scale admits." The whole work was, of course, based on the Great Triangulation, which depended, after November, 1828, on the length of the Lough Foyle Base. A certain number of points were intersected from the principal stations, and we may suppose that the officers who were responsible for the "interior survey" were given the bearings and distances of points some ten miles, or so, apart. "The subsidiary Triangulation for determining the Interior Points for regulating the Survey being to be performed

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by the District Officers, who will combine with that operation the determination of a good series of altitudes." In 1833 al trigonometrical work was placed under a special division. Th detail was surveyed almost entirely by chaining; traversing wa not generally allowed. From trig.-point to trig.-point the chai was dragged; the interior of the triangles being also split up b chained lines. Every boundary line was chained and all importan features. Traversing, though not absolutely forbidden, was dis couraged. Even in the towns the detail survey was carried ou by simple chaining. An exception appears to have been mad in the case of the survey of winding streams in deep valleys, and generally, traverses became allowable in uncultivated and woode districts and in the mountains. But, for towns, the probibitio appears to have remained in force until 1897; and much ingenuit used to be displayed by the surveyors in carrying out the surve of close towns by right lines.

"The plotting is to be performed on sheets capable of containing a least ten or twelve square miles. . . . The Trigonometrical Points are t be pricked off on the paper before the plot is commenced. . . The Plan are to be co-extensive with the Parishes, each Plan containing a singl Parish, except in cases where Parishes are so small that two or mor may conveniently be put together. . . ."

Since the areas of Baronies and Parishes were required as wel as those of the Townlands, instructions were given that the chai lines should be laid out chiefly with reference to the larger divisions Hence long lines were not uncommon; in the example given i the pamphlet there is a chain line over three miles long, an many were longer.

The areas were calculated, and not measured from the pla as they are in modern Ordnance Survey practice. A later artic reads, "In the first article of these Instructions it is directed tha the survey shall be performed on a scale of six inches to a mil and with all the accuracy of detail which that scale admits. I is not, however, intended to put in the Fields generally, but wit this exception everything attached to the ground is to be inserte on the Plans."

In accordance with the instructions of the Select Committe the early six inch sheets did not show the field boundaries, excep where they coincided with the townland or other administrativ boundaries. Larcom, writing in later years, says:

"At this time (1843) another circumstance had arisen; the earl Northern Counties had not been surveyed with the degree of deta which had been attained in the South, when the men and officers ha attained greater experience and skill. The tenement valuation, no introduced, for the Poor Law, required this detail accordingly on th Memorials of the Northern Counties; the Government allowed the Map of them to be revised."

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"The persons employed on the survey" were to endeavour to obtain the correct orthography of the names of places by diligently consulting the best authorities within their reach; the various modes of spelling a name were to be given and the authorities quoted.

"The boundaries of the several legal and ecclesiastical divisions of Ireland" were to be pointed out to the officers, "by persons authorized and directed to shew them by His Excellency the Lord Lieutenant: and the District Officer is to send to notify the times and places" where these persons' services were required. Precise instructions are given that no boundary is to be surveyed unless it is completely marked and pointed out on the ground.

The Committee of Enquiry of 1828.—In its early days the Ordnance Survey of Ireland was by no means universally popular. Local surveyors naturally felt that their bread and butter was being taken away from them. There were those who looked upon the whole undertaking as a piece of State interference. It is probable also that the Boundary Department would have liked to carry out the work itself; certainly the two departments did not get on well together. And many looked doubtfully upon the employment of soldiers. Captain Waters writes to Colby from Londonderry, on 28th March, 1828:—

"I do believe that the greater Part of the Civil Engineers of Ireland are hostile to Our having the Survey; that from the intercourse they have with the Gentlemen of the Country an Opportunity is afforded of poisoning their minds as to its accuracy, and that the idea of employing Soldiers to execute what they alone imagined themselves qualified to undertake is a disparagement which they cannot well brook."

Then Colby introduced a new system, and even some of his officers failed to give him the support which he needed, and advocated systems of their own. It was inevitable that complaints should arise from many different quarters. Misrepresentations appeared in the press. Accusations of extravagance and inefficiency were made to the Board of Ordnance. As early as February, 1826, only a few months after the survey was started, Sir Henry Hardinge wrote from the Board of Ordnance to Colby:—

"I have received a letter in which it is stated that 'the whole of the Survey in Ireland has failed.' I do not attach, of course, much importance to this Statement, but I beg to remind you of my recent request to be furnished with an account of the progress made in the Survey. . ."

Colby was indignant at the rumours, and wrote to the Board of Ordnance. Hardinge gave Colby some very sensible advice in a letter dated 22nd April (probably 1828). He says:—

"I consider . . . . that every Dept^{t}. in employing its officers ought to give them its support, most especially in the case of rumours and reports not proved. But, on the other hand, when the rumours

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admit of clear demonstration, the Person attacked ought to be most forward in courting enquiry and challenging proof. In short, the doubtful must be satisfied, and where the *exact sciences* are the subject of dispute, the only way of dispelling prejudice and unfairness is to come to the proof. Now the rumour that the Survey of Ireland is not properly conducted gains ground—persons high in office have received impressions that yr. *system* is wrong and liable to error. This is a point that I would grapple with. Officers of your own Corps as well as Civil Surveyors give it against you. This surely is capable of Demonstration. Secondly, it is stated that Errors to a large extent do exist owing to this Defective System of calculation (not to the Boundaries), and again, I say, call for one, two, or more instances to be specified—calculate the contents in different ways (the boundaries remaining the same), and ascertain whether the attack be just or unjust. . . If you are supine or passive, you will in a short time longer have such a mass of prejudice to contend with that yr. position will be uncomfortable : by challenging and seeking Enquiry, and making it yr. own act, you get rid of that awkwardness."

The upshot was that, on the 14th July, 1828, the Board of Ordnance wrote this letter to Colby :—

SIR,—In consequence of the continued reports of which you are aware respecting the Survey in Ireland, the Master General has given directions to Major-General Sir James Carmichael Smyth, assisted by Lieut.-Colonel Sir George Hoste, to proceed there immediately, for the purpose of enquiring into the state and progress of the Survey, with instructions to ascertain whether any better mode can be devised for the future conduct of it.

And I am commanded by His Lordship, in acquainting you therewith, to desire that you will attend to such communications and directions as you may receive from Sir James Carmichael Smyth in fulfilment of the Mission with which he is charged. I have the honour, etc.—DOWNES.

Sir James Carmichael Smyth was a distinguished Royal Engineer Officer, who was born in 1779, and was thus 49 years old when this duty was thrust upon him. He had served with Sir John Moore at Corunna, and had been on Wellington's staff at Quatre Bras and Waterloo. He became Governor of Bahamas, and, later, of British Guiana, and died at Demerara in 1838. He was a good soldier, capable and popular, but it was not likely that he could teach Colby anything about surveying, though, being an R.E. officer, he probably thought that he could.

Portlock, always a friend, writes to Colby on 26th July :—

" I should not intrude upon you at this moment did I not conceive that the expression of undiminished attachment and fidelity to your cause cannot be unwelcome. Alarming as this crisis is, I do not despond. Your cause must triumph over the efforts of a despicable cabal. All I trust is that you will not allow such petty and repeated vexations to tempt you to resign. That is, I doubt not, their hope. . ."

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Well, the Committee went over to Ireland and made their report, in which the principal recommendations were that the areas should be measured from plots on the 12-inch scale and that a sytem of traversing round the boundaries should be adopted. Colby resented the method of enquiry by which the Committee usually examined his officers, as it were secretly, and not in his presence. He writes to Sir James Smyth on the 3rd September, 1828, as follows:—

"Instructions as to the mode of carrying on the Survey coming with the Master General's authority relieve me from a heavy responsibility, and must, therefore, be highly acceptable. But in those you read privately to me yesterday, there is no direction to provide the additional number of theodolites required for traversing boundaries, and the checks which I am to direct to ensure the accuracy of that mode of surveying were not enumerated. In the direction to compute the areas of the townlands from paper solely, the number of independent plots from which the computation is to be made and the scale of the content plot . . . were not mentioned. The Boundary remark Books are not directed to be preserved or sent to Mountjoy, and thus the check on the boundary department is done away without any apparent saving of time or money. . . . "

Portlock says that during the progress of the enquiry he was camped upon Cuilcagh, engaged upon the triangulation. Cuilcagh is a mountain 2,180 ft. high, 12 miles S.W. of Enniskillen. It commands "a vast number of churches and other points connected with the district triangulation, and thereby assisting to furnish bases for the surveys of about 20 counties." Colby took the two commissioners up this mountain in order that they might see for themselves the trigonometrical methods in use and might question Portlock. The latter writes:—

"If, as they certainly did, they toiled, panted, and blowed upon their ascent, envying, no doubt, the elastic and never-faltering step of their more experienced comrade [Colby], they appeared, on arriving at the summit, to forget their fatigue and to be repaid for their exertions. . . Both Sir James . . . and Lieut.-Colonel Hoste expressed the highest admiration of what they saw: but alas! whilst they praised the executive officer, they overlooked or failed to appreciate the merit of the man who had planned the work which the other executed, and thus fell into that error which has been only too common in estimating the services and talents of General Colby."

Colby's views on the report are expressed in a letter to an unknown correspondent:—

"You are well aware of the vehement prejudice which exists against me at the present moment: and that any representation coming from me for the purpose of relieving the Irish Survey from the deadly wound it has received from Sir James Smyth, would merely be treated as an emanation from my wishes to have my own way. . . . To a superficial observer the changes effected by the Master General's orders may appear

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only a sacrifice of a certain portion of accuracy and completeness of information to an increase of celerity. But where upwards of 700 persons have been cautiously trained to a system, with a view to give the division of labour its most beneficial effect, the slightest change, which would pass almost unnoticed by a single executive officer, operates as a powerful check on the aggregate."

In another letter from Portlock to Colby of the 24th October, we find:—

"Larcom has told me the result of the investigation, and whilst I deeply feel for those parts which must be unpleasant to you, I see in the whole enough to support you against the whole cabal. They have not dared to impugn the System, they have given an admirable testimony to its merits."

But Colby was by no means happy about the business. In January, 1829, he says that the Survey

"is languishing under the baneful effects of the late investigation. . . The two main difficulties to be overcome in the Irish Survey were: the vague and careless manner in which the Boundaries were laid out by the Boundary Department under the Irish Government, and the vehement desire of the Engineers to make apparent progress without due regard to the character and quality of the work. My task in compelling all parties to do their duty was most irksome and invidious."

He goes on to say that he always felt sure of support as long as the Duke of Wellington remained Master General. And he points out that the new instructions have had a marked effect in reducing output.

But things settled down. The order about traversing seems to have been withdrawn; and, as to measuring areas on paper, that is Ordnance Survey practice to this day, though the 12-inch scale is not used. In November, 1829, Sir Henry Hardinge writes to Colby, "I was happy to hear you are getting on prosperously with the Irish Survey." And there we can leave the Committee of Enquiry, which did less harm than might have been expected, but left behind it in the Ordnance Survey a departmental dislike of traversing, as of some slack and irregular method, which no decent surveyor would make use of if he could possibly employ another.

The Triangulation of Ireland.—There are thirty-four stations in the great triangulation of Ireland, rather more than one per county; they are all hill stations and the height of most of them is considerable. The highest is Brandon, in County Kerry, which is 3,119 feet above the sea. Next in height is Galtimore, 3,007 feet. Then there are Baurtregaum, 2,788 feet; Slieve Donard, the same height; Mount Leinster, 2,602; Knockmealdown, 2,601; Knockanaffrin, 2,470; Kippure, 2,465, and so on. The average height of these 34 hill stations being about 1,850 feet above sea level.

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Two rays, Slieve Donard-Cuilcagh-Tawnaghmore, are sufficient to cross Ireland from the Irish Sea to the Atlantic. Three rays, Slieve Snaght-Cuilcagh-Keeper-Baurtregaum, cover the length of Ireland from the north to the south-west. The longest ray in Ireland is that from Cuilcagh to Keeper, which is 102 miles long; the next longest is that from Keeper to Nephin, which is over 98 miles long. From Cuilcagh about half of the country—that is, the centre and north—can be seen; and from Keeper the centre and the greater part of the south. So that from these two stations almost the whole of Ireland is visible. In the *Account of the Principal Triangulation* it is stated that the station of Slieve League, a mountain nearly 2,000-ft. high, in the extreme south-west of Donegal, was marked by a pile of stones, which "indicates the spot where the great instrument was once in position on the wildest headland probably in Great Britain or Ireland."

Practically all the angles of this triangulation were observed by Captain (afterwards Major-General) J. E. Portlock, R.E., with the 3-ft. theodolite B.O. (Board of Ordnance); the instrument, that is, that was made to the order of the Honourable Board and was first used in 1791. All this work was finished by Portlock by 1832, and the triangulation was then looked upon as completed, though, in the forties, two stations were revisited and three more were added to Portlock's. The probable error of a single angle was about two seconds.

And here, perhaps, a note as to what purpose the triangulation of Ireland was meant to serve may not be out of place. It was never seriously attempted to use the work in the determination of the figure of the Earth. The best proof of this is that, in the whole of Ireland only four latitudes were observed, and these not until 1843. The object of the triangulation of Ireland was the purely practical one of providing an accurate basis for the 6-inch maps.

The County Meridians.—There is a technical matter with regard to which we can say definitely that our predecessors were unnecessarily strict. In Ireland it was arranged that each series of 6-inch sheets for any one county should be plotted, independently of those of other counties, on a meridian chosen for that county. The method of plotting, that is, "the projection," was the following:—A central meridian was selected and this was represented on paper as a straight line; some point on this meridian was chosen as the origin. Then the position of any other point was fixed by the length of the great circle on the earth's surface, from the point in question, perpendicular to the chosen meridian; and the other co-ordinate was the distance along the meridian from the foot of the perpendicular to the origin. The great circles

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mentioned were plotted as straight lines at right angles to the central meridian. In this projection, which is an excellent one for the purpose, there is very little error in an east-west direction. But the error in a north-south direction increases approximately as the square of the distance from the central meridian, owing to the fact that, in nature, the great circles converge, whilst on paper they are plotted as parallel straight lines.

Our predecessors were well aware of the existence of this error, but seem to have been unnecessarily afraid of it. By limiting the area plotted to a single county they certainly reduced the resulting error to an altogether negligible quantity; but they might have been much bolder. The multiplication of meridians has the great disadvantage that there is discontinuity at every county boundary. The maps were, therefore, published county by county, and there is no detail shown beyond the county boundary, so that there is much waste paper.

If we take the meridian 8° W as a central meridian for the whole of Ireland, and measure from this meridian, we shall find that the greatest extension of land eastward is less than 105 miles, and the greatest extension westward is less than 115 miles. If the whole of Ireland were plotted on this one meridian, the greatest error of scale due to the projection would be less than 1 : 2300; and this error, by a device which need not be described here, could be reduced to less than 1 : 4600, and in computing areas this small error could be allowed for. The six-inch maps of Ireland might, therefore, have been plotted on one single meridian, instead of on 32 meridians—one for each county; and time, money, and inconvenience might have been saved. But to say this is not to undervalue that remarkable work, Colby's six-inch survey of Ireland, but only to point out that, in one particular, it suffered from what appears to us, nowadays, as an unnecessary scrupulosity.

Progress of the Six-inch Map, 1829-1839.—Although the Smyth enquiry caused some delay, the field work of the six-inch map seems to have recovered in the course of a few years; but the rate of execution was not as rapid as Colby had originally hoped for. However, by the end of 1839, the work was very well advanced, and this was its state:—About three-quarters of Ireland, from the extreme north down to a line including Galway, King's County, Queen's County, Carlow and Wicklow, had been surveyed in the field. The six-inch sheets of the northern half of the country had been engraved and published. Only two counties had not been taken up, namely, Cork and Kerry. It would not now be many years before the whole undertaking was finished.

The maps were beautifully engraved; indeed, the engraving is so fine that it is difficult to reproduce it. During the greater

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PORTION OF THE FIRST 6-INCH ORDNANCE MAP.

LONDONDERRY SHEET 20.

Surveyed in 1830. Engraved in 1831, at the Ordnance Survey Office, Phœnix Park.

(Lieut.-Colonel Colby, F.R.S., &c., Superintendent).

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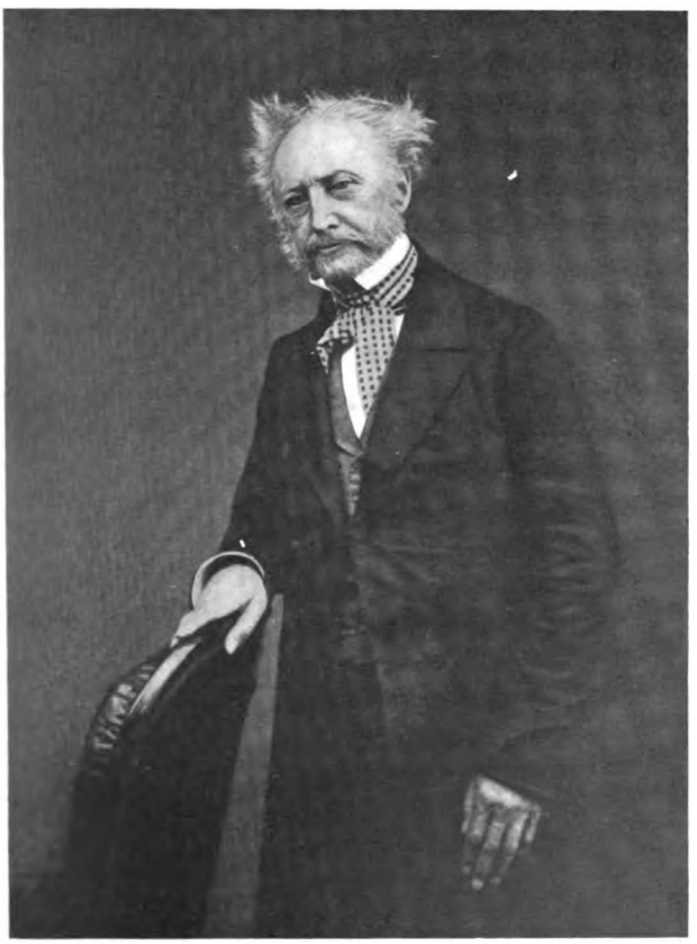

MAJOR-GENERAL J. E. PORTLOCK, R.E.,
LL.D., F.R.S., F.G.S., &c.

1794–1864.

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part of this period the headquarter office at Mountjoy was under the charge of Lieut. T. Larcom, an officer of exceptional capacity. The engravers were: McCoy, Sandys, Macaulay, Duncan, Fraser, Chisholm, Aikman, Oldham, Darling, Sergeant West and Corporal Keville. The first county to be engraved, Londonderry, with an area of over five hundred thousand acres, was finished in 1832; and, as we have seen, the sheets of this county were submitted by Colby to King William IV, in May, 1833.

These early six-inch sheets show no contours; occasional heights are marked in feet, reckoned from low water; but the Irish datum was not exactly fixed until 1837. The various county, barony, parish and townland boundaries are very clearly shown, as, of course, was necessary, for the determination of these boundaries was the original main purpose of the map. The sheets have a very characteristic appearance, not only from the fineness of the engraving, but from the abrupt endings of the minor roads, and the number of circular, pre-historic "forts" which are scattered over the surface of the countryside. These interesting relics of the past average about fifty yards in diameter, and one may say that there is a "fort" in every two or three square miles. There are probably at least ten thousand of them in Ireland.

Portlock.—Nearly all the observations on the mountain tops of Ireland, for the Great Triangulation of that country, were taken by Portlock. His career is an interesting one to study, for it combines, to a remarkable degree, soldiering, surveying and more abstract science. He was born at Gosport in 1794, and was the son of Captain N. Portlock, R.N., who was one of the loyal colonists of America. The elder Portlock had entered the Navy as a midshipman under Captain Cook and was with him at his death. The son, Joseph Ellison Portlock, the subject of this notice, was educated at Tiverton and thence went to the Royal Military Academy and obtained his commission in 1813. The next year he took part in the siege of Fort Erie, in Canada, and for the greater part of the time was the only engineer officer in the trenches.

"He constructed the lines and *tête de pont* of Chippewa, at which Lt.-General Sir Gordon Drummond made his successful stand and saved Upper Canada. For his services on this occasion Portlock was thanked in general orders. He was afterwards employed on numerous exploratory expeditions. Portlock Harbour in Lake Huron was named by Sir Gordon Drummond in memory of Portlock's services."*

In 1824 he was posted to the Ordnance Survey and became Colby's confidential friend and companion, and in 1825 he commenced his work on the triangulation of Ireland, by taking part in the observations on Divis. In 1826 we find him on the very

* *Dictionary of National Biography.*

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exposed station of Slieve Donard, in County Down; and in 1828 he remained in camp, on the top of Slieve League, in County Donegal, 2,000 feet above the sea, until the middle of January. The Great Triangulation was practically completed by him in 1832. He then directed the operations for the minor triangulation and organised an elaborate system of vertical observations for altitude. In the same year, 1832, he undertook a survey of geology and productive economy for Ireland. He had many difficulties to contend with; as he said himself, "Geology was permitted not commanded." In 1837, he formed, under Colby, a geological and statistical office as a branch of the Survey. It had been intended to publish elaborate memoirs of all the counties, but after the publication of one volume of the series, this was stopped on financial grounds. The Geological Survey was, later, resumed.

Portlock's memoir of Londonderry was the commencement of the Geological Survey of Ireland.

Sir Roderick Murchison, then President of the Royal Geographical Society, speaks thus of Portlock in his address of May, 1864:—

"This volume of Portlock's on the geology of Londonderry is a perfect model for fidelity of observation and minute attention to phenomena. To the quickness of his eye, and his resolution to surmount difficulties, we also owe the first detection in Ireland (Tyrone) of those trilobites and other organic remains which enabled him to identify these rocks with the Silurian rocks of England and Wales very shortly after my first classification of these older palæozoic rocks. . . . He was, in truth, a geologist quite after my own heart; for in him an acquaintance with rocks, minerals, and fossils was united with the full knowledge and feeling of a true physical philosopher."

Murchison then quotes Sir Thomas Larcom, who was Portlock's friend and contemporary on the survey:—

"The characteristics which shone forth in Portlock during his well-spent life, whether as a soldier, a geographer, or a geologist, were undaunted courage in facing difficulties, Spartan endurance and invincible perseverance in overcoming them. Endowed, when in the zenith of his career, with a frame and nerves of iron, he exhibited such a vast power of continuous labour that he achieved every object he had in view; whilst great ability and a pure love of knowledge were in him guided and governed by the highest sense of honour and moral rectitude."

In 1843 Portlock's work on the Survey of Ireland came to an end. It appears that about this time Colby and Portlock no longer saw eye to eye, and it must be admitted by the truthful historian that Colby had rather a knack of quarrelling with his officers; at least, that was the case with Drummond, Reid and Portlock, all very able men. But, however that may be, in 1843 Portlock, who was then 49, was ordered to Corfu. In 1849, he was C.R.E. at Cork; in 1851, he was appointed Inspector of Studies at the

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R.M.A. In 1856 he was C.R.E. at Dover, and in 1857 he was appointed a Member of the Council of Military Education. He retired in that year, but retained his post till 1862.

Whilst he was at Woolwich he wrote the *Memoir of the late Major-General Colby*. Colby died in October, 1852; the first instalment of the memoir appeared in the R.E. *Professional Papers* for 1853, and the memoir was continued in 1855 and '56. This account is more than a biography, and contains a good deal of technical information in addition; but it is, perhaps, most useful now in its main purpose of throwing light upon the life and character of Colby. If it were printed in large print it would make quite a substantial book, for it contains some 90,000 words. Portlock's own character comes out very well in this memoir, which was written in pious memory of his old chief, in spite of the fact that Portlock did not feel that, in later years, he had been very well treated by him. He says at the very end of the memoir, in admirable words:—

"In my early connection with the Irish Survey, I was his chosen assistant and confidential adviser. . . . In the later period of my connection he was estranged in feeling towards me; but as I now look back on the past from a more distant point of view, I cannot doubt that there were faults on both sides . . . and feeling that the early kindnesses and services I received from him far outweigh the later harshness. . . I am proud to have had the opportunity of recording my respect for the memory of a man towards whom, when living, I always felt and expressed affection."

From 1856 to 1858 Portlock was President of the Geological Society of London.

He died at his home near Dublin in 1864, aged 70.

There is a curious letter from Portlock to Larcom, who preserved it amongst a collection of letters now bound together and kept at the Ordnance Survey Office. Larcom was six or seven years younger than Portlock, who writes in 1826 from camp in the north of Ireland, evidently suffering from ague:—

"My dear Youth, I am, of course, better to-day, and must for a time live on hope. I send you Yule's Diagram of Points. [Then follow some technical instructions.] Take care of yourself. I drink hard for security. Not that I recommend Intemperance. Sim ought to have known better than to drive the Pegs too low. Ever, my dear Youth, Your miserable J. E. PORTLOCK."

On October 12th, 1826, he writes to Larcom from Sleibh Donard:

"My dear young Gentleman,—On the opposite whole margin you have the necessary data for Holyhead. Those for Snowdon I shall despatch To-morrow or next day addressed to you at Carnarvon. . . I hope to be off myself in the course of next week. Drummond has made good his footing: he looks very unwell and would have acted more wisely had he remained below."

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On the opposite page are instructions for setting the instrument at Holyhead station so as to intersect the light on Sleibh Donard.

There is a bundle of letters from Portlock to Colby, written between 1825 and 1829, almost entirely about the trigonometrical observations. From Newtown, Limavaddy, November 18th, 1825, Night :—

"Wind is now so constant either from one quarter or another that it is impossible to observe without a Tent. . . November 19th, My Tent still standing though almost every Cord has been broken and repaired."

Knocklayd (1,677-ft.), in Antrim, July 15th, 1827 :—

"There is as yet no improvement in the Weather as regards observations. Morning after Morning I have had the mortification of seeing the Horizon shrouded in mist or fog and the Sun rising high before he could break through. . . My only dread is that, deceived by the lovely weather, you may feel a difficulty in fully estimating the extent of haze which surrounds this Hill."

From the same station, August 17th :—

"Yesterday and this morning I have had several takes of Ben Lomond, most, indeed, hazy, but two or three very fair and the whole giving a mean difference only 2″ from what it ought to be according to the former angles. Cairnsmuir has not again shown itself sufficiently clear."

From Sawel (2,228-ft.) in County Derry, September 18th, 1827 :—

"I avail myself of some Clouds, which, I hope, will be passing, to write you a few hasty lines. You certainly carried with you the observing weather, as nothing important has been done since. Friday and Saturday, constant Fog. Sunday baffling clouds, a few Donegal Points in the Afternoon. . ."

Slieve Snacht (2,011-ft.), in County Donegal, October 4th, 1827 :—

"I am told that the Weather is free below, and I rejoice for all your sakes that it is so. Here we have an interminable Fog. The Night is likely to be wild, but we are so secured by huge Stone Traverses that we have nothing to fear. . . "

Cuilcagh (2,180-ft.), in Fermanagh and Cavan, June 25th, 1828 :—

"On Friday last we met with a singular accident. It was a stormy, unsettled day, but one, during the intervals of Showers, very favourable for churches, and I was, therefore, fixed to the Observatory. A violent hailstorm came on, and I was just stooping to take up one of the Microscope leaps, my head being near the open side of the Observatory, when I received a smart Slap (as it were) on the top of my head from a passing flash of Lightning, and raising my head, somewhat surprized, I just saw Gunner Phibbs who stood in front (being watch) roll round and tumble to the ground. He rose again, but instantly fell and remained in a kind of torpor, breathing heavily, for about twenty minutes, when he began to recover. He seemed stupefied and quite unconscious of the true cause, feeling as if intoxicated and fancying that he had slept on his Post. As soon as he could walk I sent him down the Hill, when he was bled."

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Writing from camp at Croghan, County Wicklow, on 3rd January, 1829, Portlock says :—

"As to Health, I heartily thank you for your kind concern about us all. . . I have little apprehension as to myself, that Bane a Fire not being admitted to my Quarters. The Men, too, are in excellent Health. ."

Kippure (2,465-ft.), in County Wicklow, July 5th, 1829 :—

"Yesterday Afternoon, at 5 p.m. I for the first time saw the Precelly Heliostat and took it twice with Lugnaquilla and Bray Head, the only convenient referring Points in sight. Clouds then cut it off, but . . we shall doubtless see it often again. . . "

This ray from Kippure across the Irish Sea to Precelly, in Pembrokeshire, is over 107 miles in length.

The letters are all much in the same strain. They naturally dwell a great deal on the weather. But Portlock evidently enjoyed the work, in spite of fog and storm, on the tops of the Irish hills.

His was an interesting life. Early in his career campaigning and exploring in Canada ; then carrying out, almost single-handed, the great triangulation of Ireland ; then soldiering in a more humdrum way in Corfu, Cork, Dover and Woolwich ; the founder of the Geological Survey of Ireland ; President of the Geological Society. Larcom uses the right word when he speaks of Portlock's well-spent life. In later years his name has been almost forgotten on the Ordnance Survey. It is hoped that the foregoing brief account of his career may serve to revive the memory of this fine old officer, who, indeed, deserves to be remembered, with Roy and Mudge, with Colby, Drummond and Larcom.

Sir William Reid.—When the Survey was begun in Ireland, in 1825, Colby placed Major W. Reid in charge of the Mountjoy office, and, in effect, in general charge of the operations in Ireland whenever Colby was called to London, as not infrequently happened. Reid was an officer of outstanding ability, who had served with great distinction in the Peninsula. But he had his own ideas as to how the Survey should be conducted, and as these differed from Colby's, especially at the time of the Enquiry of 1828, he left the Survey at the end of that year. So far as the Survey is concerned, we do not again come across him until 1850, when he did the Department a very good turn by recommending Lt. Alexr. Ross Clarke for employment on it.

Reid became, successively, Governor of Bermuda and Barbados, then Chairman of the Executive Committee of the Great Exhibition of 1851, and finally Governor of Malta. He died in 1858, aged about 67. He was the author of Reid's *Law of Storms*, and was a Fellow of the Royal Society.

Sir Thomas Larcom.—Good men seem to have been common in those days ; Colby found to succeed Reid an officer who was in every way fitted for the post, and who, in after years, took

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a large part in shaping the history of Ireland. Thomas Aiske Larcom was born in 1801, and after a brilliant course at the R.M Academy, was commissioned as 2nd Lieutenant in the R.E. 1820. He was posted to the Ordnance Survey in 1824. Whe Reid left, Larcom took his place at Mountjoy.

"Here he soon had the work in his own hands. He organised t large body of civilians and soldiers required for the multifarious operatio of compiling, engraving and publishing the county maps of Ireland, t beauty of which has never been exceeded; adopted the electroty process, and introduced the system of contouring. Mountjoy becar a centre of scientific education, and the resort of scientific men."*

During his 18 years at Mountjoy he served on many committe and commissions, and made use of every opportunity to increa his knowledge of Ireland. He took immense interest in all th concerned Ireland—history, archæology, language, literatu topography, place-names, folk-lore and what not. He acquir a wonderful fund of information about the country and peop which was afterwards to serve him in good stead.

In 1846, when the original six-inch survey was complete Larcom left the Survey and became a commissioner of pub works. In the Great Famine he was appointed chief director relief works. In 1853 he was appointed Under-Secretary f Ireland, and he remained in this post until 1868. It is a testimo to Colby's good judgment in the selection of his officers that t of them, Drummond and Larcom, became the virtual rulers Ireland. "Larcom, adopting the policy of his friend Drummon undertook to govern all parties alike with even-handed justi to remove abuses and prevent disorder."

"If he had been Viceroy for those sixteen years, he could not ha been more entirely identified during that time with the governme of Ireland. Each of those great officers. . . . Whigs and Tories alik vied with each other in their recognition of his services. Men like Lo Clarendon and Lord Mayo were his enthusiastic friends; splend gifts of plate, and flattering addresses were presented on his resignatio and, till the infirmities of old age intervened, he was frequently consult upon Irish affairs by subsequent Governments."†

Besides being a clever man, he was evidently a very industrio and methodical one. It is said that there are hundreds of bou volumes of his notes and memoranda on a great variety of subject most of these volumes have passed to various learned societ in Ireland. There are four volumes of letters, with his not now in the Ordnance Survey Library at Southampton; thr

* *Dictionary of National Biography.*

† *Edinburgh Review*, No. 336. Quoted in Whitworth Porter's *Hist of the Corps of R.E.* Vol. II.

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of these deal with contouring, and one with levelling. The volumes are full of technical interest; one volume, in particular, contains a valuable series of examples of various methods of depicting hill features—experiments which range from 1824 to 1847. Some of these have a curiously modern look.

On his retirement Larcom was created a baronet and an Irish Privy Councillor. He had already been made a K.C.B. He died in 1879.

Here is a letter from William Denison to Larcom. Denison (afterwards Sir William Denison, and some time Acting Governor-General of India) was, when he wrote this letter, the first editor of the *Professional Papers of the R.E.*

Woolwich, March 4th, 1841.

My dear Larcom,

There is some comfort in corresponding with you: one always gets some encouragement or assistance, while from others one too often meets with just the reverse. I must say that with some few exceptions I have met with a very small allowance of support or assistance from my Brother Officers; no one seems ever to think that his comrades may be benefitted by the information he may have in his possession, and consequently everyone waits till a subject is actually suggested to him before he thinks of putting pen to paper, though were he conscious of the benefit it would be to himself in perfecting and extending the knowledge of the subjects he is conversant with, he would make a practice of embodying his knowledge in the shape of a paper. This, however, is a mere expectoration of bile. . . .

I am glad you are pleased with this volume. I hope to get something from Alderson about Acre. I saw a letter from him to Fox giving a very clear account of what was done there, and some very sound remarks about Sea Batteries when exposed to such heavy fire as is now brought to bear against them. . . . I was not aware of what you have been doing about contouring, but I am rejoiced to hear that you have succeeded in introducing it, upon the six-inch scale; it is the only mode of showing the ground. I have long been an advocate for it upon Plans of any size—on a small scale it would be absurd, but on the six-inch it will give you an enormous mass of information at a glance, relative levels, shape of ground, etc. I think it would be well worth a paper and should be very glad if you would take it up. . . . Shall you be able to establish your levels all round Ireland with the necessary degree of accuracy for general Tidal observations? Is there not a dispute as to the Sea Level? What do you take as your datum line? I have not seen the results of Whewell's work at Bristol; he seemed to have taken very great pains in his levelling. . . .

Thanks for your memoir of Hogan. I like the style of the figure of Dr. Doyle, though I dislike the allegorical figure of Ireland. I hope he will do justice to Drummond. I am working away in the Dockyard here. I am rather short for money this year.

Yours very truly,
W. DENISON.

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Irish Place-Names and John O'Donovan.—In the course of the survey of Ireland it became necessary to ascertain the correct forms of spelling of the Irish place-names. This was no easy task. In every country the lapse of time results in a gradual corruption of place-names; but in Ireland, in addition to this natural cause of error, there was an artificial cause, due to the orders of the English Government in the seventeenth century. Larcom quotes an order of King Charles I, which states that the "barbarous and uncouth names of places" in Ireland much retard the reformation of the country, and directs "the Lord Lieutenant and Council to change such names into others more suitable to the English tongue, annexing the ancient names in every grant so altered." Colby fully appreciated the importance of getting correct forms, and, when Larcom took charge of the Mountjoy office, the latter threw himself heartily into the difficult work of restoring the names. Larcom says, "as for the orthography of the names engraved on the maps of the Ordnance Survey, the different spellings and *alias* names of every townland were collected from all accessible documents, some . . . . of very great antiquity; and, finally, local enquiry and examination were made by an Irish scholar on the spot, to render the name ultimately adopted as nearly as possible consistent with the ancient orthography."* All this information was collected in *Name Books*, which now form a priceless record of Irish place-name study. Again, Larcom says that the full results of this investigation will only be seen in the future; it arose "from the desire to ascertain a correct orthography for the numerous names of places, more especially parishes and townlands, which alone amount to nearly 70,000. . . . These names were commonly of Irish origin, and frequently of great antiquity. Lieut. Larcom first began himself to study the Irish language, and investigate the names as they arose, but this was obviously insufficient."* Many of the names

"were in Latin, many in Irish, contained frequently in M.S. charters and grants. When all had been collected that libraries and records could furnish, an investigation by a qualified Irish scholar was made on the ground, where, by additional inquiries, conversation with the old inhabitants, and examination of the locality, little difficulty was experienced in discovering the meaning of the name, and its correct orthography. . . . the practice was to adopt that one among the modern modes of spelling, which was most consistent with the ancient orthography. The documents thus collected form in themselves a most valuable topographic library, such, perhaps, as no country in Europe possesses in the same condensed form."

The chief of the Irish scholars mentioned above was John O'Donovan. An excellent source of information with regard to

* Portlock's *Memoir of General Colby.*

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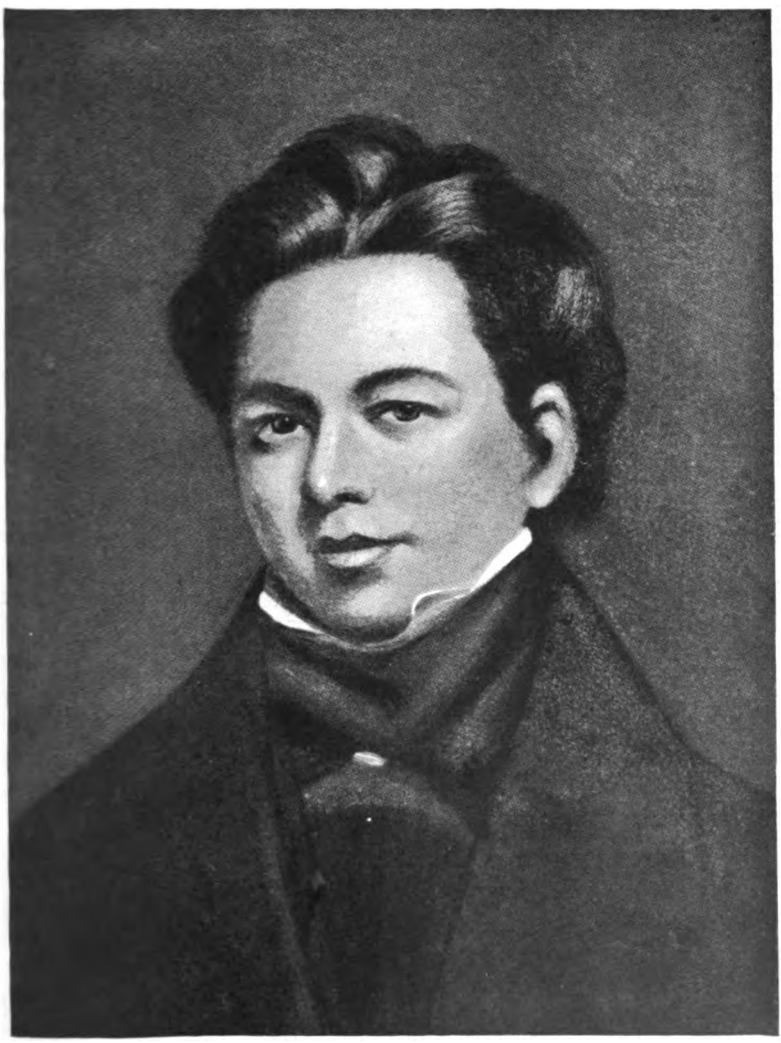

JOHN O'DONOVAN, LL.D.
1806–1861.

From a portrait painted in 1838 by C. Gray, R.H.A.
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his life is the account written by Mr. Henry Dixon in *An Leabarlann** for April, 1906. What follows is based, by permission, on this source, which should be referred to by all interested in the subject.

John O'Donovan was one of the five sons of Edmund O'Donovan, who belonged to a family that had settled in Kilkenny early in the seventeenth century. John was born at Atateemore in July, 1806. His father died when John was eleven. It is said that it was from an uncle that he first caught "that love for ancient Irish and Anglo-Irish traditions" which he preserved all the rest of his life. He says himself that he "transcribed Irish pretty well in 1819." Early in 1821 he was sent to school at Waterford; and in 1823 he went to a Latin school in Dublin, where he remained until 1827. In 1830, whilst staying in Queen's County for his health, he made extracts from the *Annals of the Four Masters* and read many books bearing on Irish history.

In this year, 1830, to use his own words, "I applied to Capt. Larcom, then Lieutenant Larcom, for employment. I had known Mr. Larcom since the year 1828, when I taught him some lessons in Irish, and he wrote to me immediately, offering me a situation at a very small stipend, of which I accepted after some hesitation. . ."

O'Donovan was immediately employed upon the investigation of place-names. The various forms of the names were written in *Name Books*, and each authority quoted. This involved much research into the history and topography of the district, in fact, here, as always, history, topography and philology went hand in hand. "To O'Donovan the work was of special import. To this work and to his great application may be attributed the wonderful knowledge of history, archæology, and topography displayed in the innumerable writings associated with his name." He was periodically sent out into the field; and, taking with him the information collected in the *Name Books*, he was able, by an examination of the locality and by questioning the old inhabitants; to fix with some certainty the correct forms of the names. "The system . . . of visiting each place was afterwards not followed out, and O'Donovan was asked to decide on the proper names of places he had never visited, a system which he protested against." His many letters to Larcom giving the results of his investigations are a mine of information on philological, historical, and archæological matters, and are frequently drawn upon.

It had been the intention of Colby and Larcom to publish a series of memoirs of the parishes of Ireland. This magnificent scheme was never carried out; or, rather, only one parish was so dealt with. This parish was Templemore in County Londonderry; and the *Templemore Memoir* was published, with the assistance

*Dublin. Browne & Nolan, Ltd.

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of the British Association, in 1837. It gives an account of the topography, geology, botany, and zoology of the parish; a description of the towns and a history of the townlands; a third section deals with statistics, social economy and manufactures. "The preface written by Colonel Colby states that the section relating to history, archæology and antiquities was written by George Petrie and John O'Donovan."

In 1845 O'Donovan published his *Irish Grammar;* in 1851-56 there was published his translation of the *Annals of the Four Masters*, with introduction and notes; in 1849 he was appointed Professor of Celtic Languages in the Queen's College, Belfast; in 1856 O'Donovan was elected a corresponding member of the Royal Academy of Berlin, on the proposition of Jacob Grimm. He died at Dublin on the 9th December, 1861, and was buried in the Prospect Cemetery. Inscriptions on tombstones are usually of too flattering a nature to be regarded as reliable material for history; but the account of O'Donovan's work on his tombstone is accurate and just. It reads:—

By his Irish Grammar, his edition of the Annals of the Four Masters, his labours on the transcription and translation of the Brehon Laws, and his invaluable contributions to our knowledge of the topography and local history of his country made during his connection with the Ordnance Survey, he laid a sure foundation for sound and scientific Celtic Studies and established his position as a master of Irish Philology and Archæology. . .

O'Donovan was helped in his investigations by all classes of his countrymen. He writes, for instance, from Belfast on 15th March, 1834:—"Dr. Crolly, R.C. Bishop of Down and Connor, has given me the following letter to the Priests of the Diocese:—

'The Bearer, Mr. John O'Donovan, is employed by the Ordnance Surveyors to ascertain accurately the old Irish names of townlands, villages, etc., for the purpose of making the general and particular Maps of Ireland, and its different counties, as perfect as possible. In this useful, laudable, and patriotic pursuit I trust that he will obtain from the Catholic clergy every assistance which they can afford in order that Mr. O'Donovan may be enabled to accomplish his interesting and important object.'"

O'Donovan's letters to Larcom at the Mountjoy office are full of interest to this day and are written in a free and natural style, very different from that of most official reports. Thus, on the 23rd April, 1834, he writes from Castlewellan:—

"I have this day made a pilgrimage to Sliabh Domanghairt [Slieve Donard on the maps, 2,800-ft. high]. I have been induced from many motives—1. To endeavour to get the names of the Mourn Mountains from its lofty summit. . . . 2. To gratify a curiosity excited in my mind by

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the gigantic appearance of the mountain itself from every part of the county, and by the following passage in Colgan's *Acta S.S.*:—' In the territory of Iveagh and Diocese of Dromore, there are two churches dedicated to St. Domangard, one (which is at the foot of a very high mountain overhanging the eastern sea) is called Rath Murbhuidlg by the ancients, but at this date Machaire Ratha ; *the other* on the *summit* of that lofty mountain, *far removed from the habitation of every human being*, and which is frequented by great multitudes of pilgrims, etc. Hence this mountain, which was called Sliabh Slainge by the ancients, is at this day commonly called Sliabh Domhangaird from this Saint.' My third reason was, I suppose, to wash off in S. Domangard's well the many sins I have committed by cursing dogs, ganders, over-inquisitive people, and petty country landlords."

Downpatrick, April 29th, 1834 :—" Please to desire Lieut. James [afterwards Sir Henry James] to insert into the *Name Books* the names of all the mountains, rocks, streams, valleys, loughs, etc., that are to appear on the maps of the barony of Mourne. . . These mountains bear very curious aboriginal names, and I am very anxious to have a perfect list of them lest I might omit any. . ."

Downpatrick, May 2nd, 1834 :—

" In the parish of Tyrella there is a townland called Ballykinler, which Vallency, Beauford, and in all probability O'Reilly, would have explained, the *Town at the Head of the Sea* . . . but as soon as I heard it pronounced by an old Irishman, I said it must mean the *Town of the Candlestick* (horrid name ! !), and silly conjecture for any sensible person ! Be it so, say I—but turn to the fact. Look at Harris's *History of the County of Down*, 1744, and you will find, Ballykinler lower, middle, upper . . . formed the parish of *Ballykinler*, the tithes of which were appropriated to Christ Church, Dublin, for WAX LIGHT. . ."

O'Donovan's letters to Larcom were presented by the Ordnance Survey to the Royal Irish Academy. The three letters above quoted are taken from *An Leabarlann*, for June, 1909, a number which deals with the letters of O'Donovan, written in 1834, from County Down.

(*To be continued.*)

ERRATA, *R.E. Journal*, DECEMBER, 1925.

On page 550, line 26, for " Offaty " read " Offaly."
On page 661, line 45, for " (a-b)/b " read " (a-b)/a."

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DEMOLITION OF THE S.S. "CYRENA," WANGANUI, N.Z.

By LIEUT. COL. J. E. DUIGAN, D.S.O., N.Z.S.C.

IN the month of May, 1925, the S.S. "Cyrena," carrying case oil and benzine from the East, while entering the port of Wanganui, N.Z., struck what was thought to be a waterlogged tree trunk on the bar of the River. The dimensions of the "Cyrena" were approximately, length 288 feet, beam 54 feet, draught 26 feet. The freighter had previously called at the port of Auckland and discharged some thousands of cases of cargo from her midship hatches. It is presumed that the back of this ship was broken when she struck the submerged obstacle owing to the fact that the weight was all in the fore and after ends of the vessel. A few hours after the ship struck she was floated off but found to be leaking badly forward of the engine room which took up the whole of the after end of the ship. The pilot in charge of the vessel decided that it would be unwise to proceed into the River entrance and she was beached a quarter of a mile to the north of the mole.

The case oil and benzine was salvaged from the ship, but heavy weather came on, causing the vessel to break in half just abaft the bridge amidships. Further heavy weather caused the fore part of the ship to be driven on to the beach about the half tide mark whilst the after portion was driven on to the north mole (see Photo 1) and threatened to break through it, thus blocking the port. At this juncture the Defence Department was approached by the Wanganui Harbour Board to demolish the wreck. The ship was abandoned by the salvage party who stripped her of everything of value. The wreck was inspected immediately on the request of the Wanganui Harbour Board and a programme of action was adopted which proved to be sound from the results achieved.

The following stores were ordered from Ordnance in Wellington and shipped to Wanganui by a coastal steamer :—

Gun Cotton Wet (old submarine mining)	4,480 lbs.
Primers 1 oz. Field dry	600
Detonators No. 13	300
,, 8	300
Fuze, slow	150 fathoms.
Boxes jointing and testing, complete ..	1
Leads, electric	3,500 yards
Exploders, Field Service	2

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Spun Yarn	200 fathoms.
Twine	1 lb.
Lashings ¼ inch	1 coil
Water proof bags.	6 to be made locally to hold 50 lbs. weight gun cotton.

After some considerable delay owing to the equinoctial gales, a party consisting of two Officers, New Zealand Staff Corps and four N.C.O's of the old Royal N.Z. Engineers, now Electric Light Section of the R.N.Z.A., commenced operations.

Calculations.

All calculations in connection with the demolition were based on the formula $\frac{3}{2} B t^2$, and this formula proved to be absolutely accurate. It would seem unnecessary to give the calculations in detail, but at the end of the demolitions it was found that 100 lbs. of gun cotton was over out of the calculated total amount of 4,480 lbs.

The scheme of operations was divided into two distinct portions :—

A—Forward Portion.

Scheme A was as follows :—

(*a*) To cut the ribs and sides of the wreck in between the forecastle and the bridge on the port side.

(*b*) To cut the deck on the port side and drop this side out to port.

(*c*) To cut the deck between the forecastle and the bridge and to drop it into the hold.

Note.—This deck was supported by 15 6" round steel pillars riveted to the keelson and deck girders. It was decided not to cut the pillars but to leave them standing, in order that the deck when cut would be thrown outwards, leaving room for the starboard side to be dropped flat into the hold.

(*d*) To cut the ribs and hull on the starboard side and let this drop to port, at the same time dropping the bridge portion outwards and aft.

(*e*) To cut the forecastle clean through in two places, up the sides and through the decks, which were three in number, and fore and aft, where it was embedded in the sand and to break the remainder up later by small charges.

Note.—As this portion of the wreck was only 600 yards from the nearest houses large charges could not be used.

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B SCHEME. AFTER PORTION.

(*a*) To place four made-up charges of 50 lbs. each in waterproof bags well down inside the hull as follows:—
One on each side of the boiler room between the boilers, two in number, and the hull of the ship,
One in the stokehold, and
One in a cofferdam forward of the stoke hold.
To fire these charges simultaneously.

(*b*) To cut through the engine room sides down to low water mark and along the decks fore and aft and necklace the funnel.

(*c*) To continue the cut across the beam of the ship and thus leave the seas to do the rest forward of the engine room.

(*d*) To cut through the stern aft of the engine room bulkhead.

(*e*) To cut the tween decks ribs, stern post and rudder pillar allowing the whole of the remains to drop down to the level of the mole.

The after portion of the wreck was tackled first owing to the danger of it breaking through the mole, as already explained. A hand trolley was loaned by the Harbour Board Engineer and the stores loaded up for the first day's work in weather that one might expect on the Coast of Biscay but not in New Zealand. It was high water with a heavy flood coming down the River, The mole was slippery and spray was breaking over the wreck. The conditions were so bad that after several attempts to place charges in position a halt had to be cried until the tide dropped. A slip by any member of the party meant injury on the rocks with every chance of being washed out to sea and incidentally into Davy Jones' Locker. As the tide dropped the seas broke outside the wreck and, with new vim and the aid of the Harbour Board Engine and a truck, the party started off again for the wreck. The four charges mentioned in (*a*) were successfully lowered into position and the party retired 800 yards up the mole to watch the effect. These charges were arranged two in series with an earth return and fired simultaneously by lashing the rack handles of two exploders to a piece of 2in. x 1in. timber.

The result was as follows:—

1. The sides were blown out for a distance of 10 ft. on each side of the charges.

2. The two boilers in the boiler room were standing on end and the cofferdam bulk heads were blown out, giving the sea a free chance to assist.

NOTE.—These charges had 8′ of water over them when fired. Further extensive damage was done by these charges and the sound

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THE DEMOLITION OF S.S. "CYRENA."

Photo 1. The after portion.

Photo 2. The after portion demolished.

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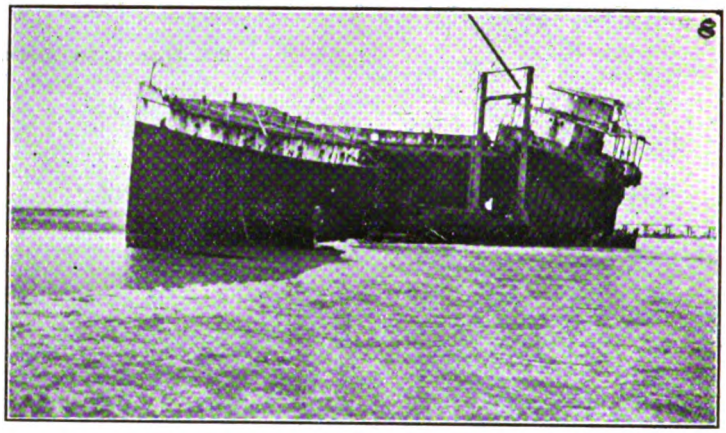

Photo 3. The forward portion.

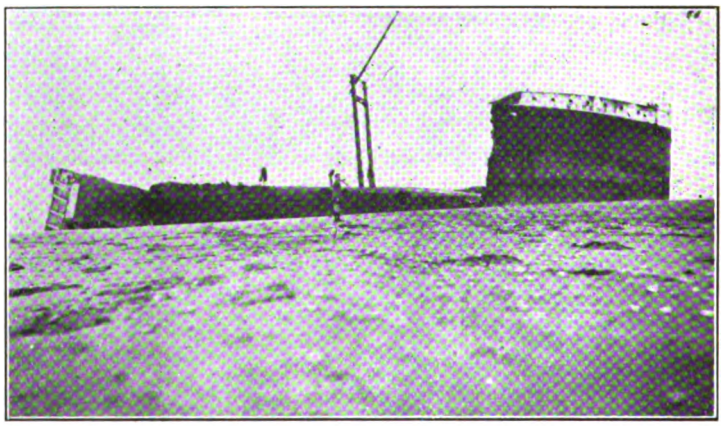

Photo 4. The forward portion demolished.

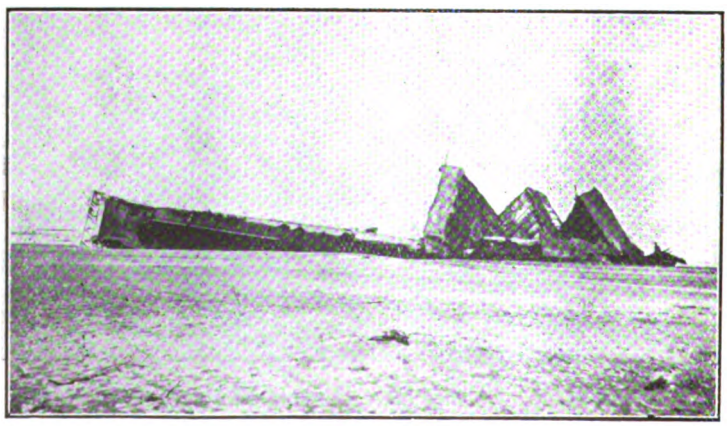

Photo 5. Final condition of the forward portion.

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of grinding steel, rivets breaking, and the bulk heads moving about with every sea showed that the underwater damage was very considerable.

On the second day of work it was decided to get rid of the funnel which was necklaced with ½ slabs guncotton and fired electrically with two detonators in series. This funnel was a most tenacious beast, as after cutting it clean through all round it defiantly stood up, held by two ½ in. angle irons, 3 in. wide, opposite each other, and it was not until one of these was cut that it decided to lower itself gently down as if lowered deliberately with a block and tackle. Work progressed slowly but surely and at the end of the six days' operations the wreck was reduced to the mass of debris shown in photograph 2.

During work on the extreme after part of the wreck, a deck cutting charge fired by fuze caught fire due to the dryness of the wet gun cotton and the manner in which the fuze had been allowed to lie along the length of the charge. When this was seen from the locomotive which we were now using for running up and down the mole, the driver put up a world's record over 400 yards. This charge detonated when the fuze reached the detonator. The Sergt. Major was asked later by the Engine Driver if he heard a piece of steel whiz past during the trip up the mole and retorted "Yes, I heard it twice, when it passed us and when we passed it."

The forward portion of the work offered more scope for ingenuity than the after portion. The plan of attack remained as originally designed and it was launched at 9 a.m. on the 7th day. It is not proposed to enter into more details than necessary but we brought two exploders into action from zero hour and commenced cutting the ribs and hull as low down as possible on the port side. An attempt was made to fire four detonators in series off each exploder simultaneously but we found that we could not rely on firing more than two off each. This meant delay and was not due to the exploders which were tested and fired through 100 ohms comfortably. No doubt the resistance of the detonators varied considerably. They had only been tested for continuity.

In cutting the sides of the ship the charges were made up by nailing the guncotton on boards about 12 feet long, as recommended in the *Manual of Mining and Demolitions*. This was found to be very successful but one must watch for close contact between the charge and the objective, otherwise the cutting effect is uncertain. Close contact with the sides was gained by cutting partially through the boards the guncotton was nailed on to, or by placing a weight against the charge, but this is sometimes difficult to arrange. In cases where it is impossible to flag off a large danger area, anything that may fly, such as angle iron, etc., should not be used to keep the charge in close contact with the object to be demolished. In one

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instance, a piece of steel weighing 10 lbs. flew 300 yards from a 15 lb. charge placed on the side of the wreck. The local press stated that steel was flying at Castlecliff and making a noise like an aeroplane. This piece did, and fell inside the danger zone 30 yards from a seaside cottage.

All the charges that had been fired on the forward portion up to this had been fired from behind a steel tank, but it was considered that discretion was the better part of valour and our place of retreat was moved to a safer place under the after end of the forward part of the wreck.

On the eighth day, cutting of the port side was completed and fell to port. The ribs and hull in the hold of the ship were cut simultaneously. Later in the afternoon, on the same day, the deck was cut out and the stanchions holding it up amidships which had been left intact, threw the deck out to port and into the side of the wreck already dropped (see photo 3.), thus leaving room for the starboard side to fall into the hold as originally projected. (See photo. 4.) It was most surprising to find that the twin masts remained standing and only the wooden topmast had suffered when the deck weighing 80 tons fell. The twin masts were next cut and fell on deck as if placed by hand. On the following day the starboard side was laid flat (see photo 4,) and the bridge portion went at the same time outwards and aft making a clean looking job and one that the demolition party were proud of. The forecastle and forward cofferdam only remained. This was cut into three pieces and left to the mercy of wind and waves, but proved very difficult to dispose of and it would have been a waste of money to cut it into smaller sections. Where possible, charges placed on the forecastle section were tamped. The value of wet sand for tamping cannot be exaggerated.

This ended the operations which I hope will be found interesting to the Corps of Royal Engineers.

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BRIEF HISTORY OF THE ROYAL ENGINEERS WITH CAVALRY IN FRANCE DURING THE WAR 1914-1918.

By COLONEL W. H. EVANS, D.S.O.

The subject is treated under the following heads :—

A. The British Cavalry Corps, formed October 11th, 1914.
B. The Indian Cavalry Corps, formed December 2nd, 1914.
} Abolished March 25th, 1916.

C. The Cavalry Corps, formed September 4th, 1916, and existing until the end of the war.

A. THE BRITISH CAVALRY CORPS.
(1st, 2nd and 3rd Cavalry Divisions.)

1. At the outbreak of the war an organisation existed for the formation of a Cavalry Division of 4 Brigades, and a Field Squadron, R.E. (afterwards the 1st), had been formed at Aldershot in March, 1914, from the 1st (Aldershot), 2nd (Chatham), 3rd (Canterbury) and 5th (Aldershot) Field Troops. There was also the 4th Field Troop at the Curragh.

2. The 1st Field Squadron (Major E. S. Sandys, Capt. P. O. L. Jordan, Lieuts. G. E. H. Sim, T. H. Foster, R. R. Egerton and R. G. W. H, Stone) mobilised at Aldershot, with the 1st Cavalry Division, on August 4th, 1914; it landed at Boulogne on August 16th, and concentrated round Maubeuge on August 19th. The Division marched north, and during the battle of Mons, on the 23rd, the Squadron prepared the bridges between Pommerœul and St. Aybert for demolition and put Quievrain in a state of defence. The next day, the commencement of the retreat, the Squadron sent back all their wheels and thenceforth acted as mounted infantry, the only R.E. work done consisting of cutting fences for the passage of Cavalry; they were in the firing line at Audrignies on the 24th, retiring to Jenlain; held Solesmes on the 25th; retiring via Beaumont, Ligny, Ronssoy, Roui Le Grand and reaching Flavy Le Meldeux, near Ham, on the 28th; on the 29th they fought a delaying action with the 2nd Cavalry Brigade round Guiscard and Crisolles, reaching Ourscamp in the evening; on the 30th, with two Squadrons of the 19th Hussars, they covered the retreat of the infantry, reaching La Croix St. Ouen in the evening, via Divisional Head Quarters at Compiègne, where they again picked up their wheels. On August 31st the Squadron prepared the bridge at La Croix St. Ouen for

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demolition and held it, retiring with the Carabineers, on September 1st, via Verberie to Mont L'Evêque; on the 2nd, the march was continued via Ermenonville to Villeneuve, where an enemy battery was destroyed and the eastern end of the village defended; the retreat was continued the next day to Gournay on the Marne, near Paris, where the Squadron got a little time to refit. On September 5th the advance commenced and the Squadron moved up via Marmand, Jouy Le Châtel, La Hante to Sablonnière where, on September 8th, the bridges were reconnoitred and the bridge at La Ferté Gauche was strengthened for M.T., the Squadron following in the pursuit to La Voue Le Prêtre; on the next day the Division were ordered to seize the crossings over the Marne at Charly sur Marne and Saulcherry; the Squadron prepared to bridge the river, but the existing bridges were found intact. The advance was continued to the Aisne, via Mont de Bonneil, Grisolles, Cramaille to Braisne, where, on September 12th, preparations were made for bridging, but one bridge was found intact; after severe fighting on the part of the Division, the advance was continued to Vauxcere and Oeuilly, where the Squadron were employed from September 14th to October 2nd on improving and strengthening the bridges over the Aisne; one of these was a girder bridge that had been partially destroyed during the retreat, and considerable difficulties were experienced due largely to the river rising. On October 3rd, the march to Belgium commenced, the Squadron moving via Quincey-Sous-Lemont, Le Plessier Houleu, Crépy en Valois, Moyvillers, Villers Tournelle, Longpré (near Amiens), Bouquemaison, Monchy Bretonne, Guarbecque, reaching, on October 10th, Vieux Berquin, which village they defended, the Division being employed on covering the deployment of the infantry. On October 13th the Squadron moved northwards, via La Flétre, St. Jans Cappel, to Neuve Eglise, on the 16th assisting the 2nd Cavalry Brigade in an attempt to cross the Lys at Ploegstreet and on the 17th reconnoitring the river at Houplines. To the end of October the Squadron were employed on trench work and acting as a Divisional Reserve to the cavalry holding the Messines Ridge; on October 30th, when Messines was lost, the Squadron were holding a farm between Messines and Wytschaete and handed it over to the Carabineers and a battalion of London Scottish half-an-hour before it was taken by the Germans, the Squadron retiring to Wolverghem; Capt. Jordan and Lieut. Stone were wounded during the action. During the early part of November the Squadron moved to Neuve Eglise and later to Dranoutre, being employed as Divisional Reserve and on trenches in front of Wolverghem. On November 11th they moved up to Ypres in support of the 1st Brigade, S.E. of Brielen. On November 13th work was started under the Chief Engineer, First Army, 2 troops being employed on a bridge S.W. of Kruisstraat

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and 2 troops with the 2nd Cavalry Brigade on trench work; Lieut. Egerton was killed on the 17th. On November 26th the Squadron was withdrawn to Thieshouk for the winter.

3. The 4th Field Troop (Capt. L. C. Trench, Lieuts. T. A. S. Swinburne and K. M. Carnduff) mobilised at the Curragh on August 4th, leaving Queenstown on the 15th, and landed at Havre on the 17th. They joined the 5th Cavalry Brigade at Aulnoy, near Maubeuge, on the 19th, reaching Boussiére on the 20th, and came into action on the 21st at Hargnies, between Binche and Mons. On the 25th the troop had retreated to Taisniéres and marching daily had reached the Oise at Chauny on the 29th, where charges were placed on the bridges and their demolition carried out on the 30th August. The Troop accompanied the Brigade during the retreat and the subsequent advance to the Aisne, where, on September 25th, the 2nd Cavalry Division was formed by detaching the 3rd and 4th Cavalry Brigades from the 1st Cavalry Division; at the same time the 2nd Field Squadron was formed by splitting up the 4th Field Troop into two troops and the addition of a troop (Lieut. Stone) from the 1st Field Squadron. The Squadron accompanied its Division on the march northwards, reaching Taux on October 1st and Caestre (near Hazebrouck) on the 12th October. Here they were joined by a strong detachment (Capt. C. R. Johnson, Squadron Commander, Lieuts. F. Preedy, G. E. Grimsdale and W. F. Pattinson), which had been raised at Aldershot, sailing from Southampton on October 10th, and disembarking at Havre on the 11th; on the 16th the troop from the 1st Field Squadron rejoined its own Squadron. The 2nd Field Squadron then marched via Westoure to Wytschaete, where, from October 16th onwards, it was employed first on strengthening the outpost line between Houthem and Gaspard, held by their Division, and later on a second line between St. Eloi and Wytschaete, to which line the Cavalry retired on October 30th. During the early part of November the Squadron were helping their Division in the line, and later on wiring a line east of Wolverghem, the Headquarters of the Squadron moving from La Clytte to Reninghels and St. Vans Cappel. After a rest of six days at Vieux Berquin, the Squadron were in the line with their Division north of the Kemmel-Wytschaete Road on November 20th and 21st, then withdrawing to Vieux Berquin for the winter.

4. The 3rd Field Squadron (Capt. C. E. P. Sankey, Lieuts. R. D. Pank, J. Kiggell and J. C. Bowles) were ordered to form at Ludgershall on September 16th; men were collected and trained at Aldershot and the squadron embarked at Southampton on October 12th, reaching Boulogne on the 14th, detraining at Hazebrouck on the 18th and joining their Division at Passchendaele on the 19th October. After assisting their Division in the line, the

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squadron were employed on second line defences east of Ypres, employing civilian labour, and afterwards worked on communication trenches, etc., for the 1st Corps; Squadron Headquarters moving during this period from Zonnebeke to Dickebusch Farm; Captain Sankey was wounded on October 30th; on the 21st November the squadron was withdrawn to Hazebrouck for the winter.

5. The British Cavalry Corps was formed on October 11th, 1914, at St. Venant, while the 1st and 2nd Cavalry Divisions were advancing in the area round Hazebrouck and covering the detrainment of the infantry sent up from the Aisne, the 3rd Cavalry Division was just arriving from England. The Cavalry advanced to the Lys position between Armentières and Warneton, and held the Messines Ridge till the arrival of the infantry, who took over about November 9th, the cavalry withdrawing then to about Merris. On November 11th the 1st and 3rd Cavalry Divisions went up to Ypres under the 1st Corps, and were withdrawn on the 20th. On November 20th the 2nd Cavalry Division were put into the line east of Kemmel, and were relieved by the 1st Cavalry Division on the 22nd, the infantry taking over shortly afterwards. The Corps then assembled in their winter area round La Motte; 1st Cavalry Division round Liettre (Field Squadron, Thieshouk); 2nd Cavalry Division round Vieux Berquin (Field Squadron, Vieux Berquin); 3rd Cavalry Division round Hondeghem (Field Squadron, Hazebrouck). The winter was spent in training, chiefly for trench warfare; experiments were carried out and instruction given in grenades and trench mortars; the ordinary R.E. services were carried out, including a good deal of road work and the construction of aerodromes at Bailleul. On December 3rd the cavalry were inspected by the King. During January the 2nd Field Squadron were employed supervising civilian labour near Hinges, constructing a 2nd line east and north-east of Bethune, and a 3rd line about the La Bassée Canal, under the Chief Engineer, 1st Corps. On February 1st Capt. Trench (3rd Field Squadron) was wounded, and on February 2nd, Lieut. Scobie (1st Field Squadron) was slightly wounded by a hand grenade. During February, for a period of six weeks, the Corps relieved French infantry (18th Division, IX. Corps) in the trenches north of Hill 60, and also helped the 28th Division; the 3rd Field Squadron were up during the first half of February and again from February 18th to 26th, handing over on the 22nd to the 1st Field Squadron, who were employed on sap heads, mines, etc., and were withdrawn on March 5th, Major Sandys being wounded on February 23rd; the 2nd Field Squadron were in the trenches south-east of Ypres from February 12th to 23rd. From March 9th to 20th the 3rd Field Squadron with dismounted cavalry were employed on trenches west of Steenbecque. The Corps stood by for the battle of Neuve Chapelle on March 10th, the 2nd Cavalry Division going up to the

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battle, one brigade being engaged. On March 25th the 1st Field Squadron moved to Hondeghem.

6. On April 21st, 1915, there occurred the first gas attack at Ypres, and the Corps went up in support of the left of the British line from Ypres to the right of the Belgian Army; the 1st Field Squadron, on the 23rd, were helping the 1st and 2nd Cavalry Brigades on the line Woesten-Elverdinge-Brielen, and on the 26th their Division supported an attack by the French on Lizerne and Hetsaas; the 2nd Field Squadron, on the 25th, were assisting the 4th Cavalry Brigade to entrench in front of Boesinghe; the 3rd Field Squadron were at Vlamertinge with their Division in reserve. Subsequently the Field Squadrons were employed on trench work, east of Ypres, under the C.R.E., 28th Division, and continued work in this neighbourhood until the end of May, sometimes working with their Divisions in the line about Hooge and Wieltje and sometimes on the G.H.Q. Line east of Ypres and the Zillebeke Switch. Between May 17th and 28th the squadrons worked together under the C.R.E., Cavalry Force (Major Sandys). During the second gas attack, on May 24th, the 1st Field Squadron had to abandon their dug-outs and man the Menin Gate trenches. The 1st Field Squadron were withdrawn on May 28th to Esquelbecq; the 2nd on May 29th to Ebblinghem; the 3rd on June 5th, to Renescure. On June 30th, the Corps went up to work, dismounted, on back trenches in the Ypres area; the 1st Field Squadron to Vlamertinge under the VI. Corps; the 2nd to Dickebusch on the Kemmel Defences, under the V. Corps; the 3rd on trenches from Hill 63 to Neuve Eglise, later going on to Elverdinge defences, which they handed over to the 1st Field Squadron on August 7th, themselves working from August 16th on trenches east of Armentières, where, on August 30th, Lieut. Theodore Smith was killed. The squadrons were withdrawn about September 5th respectively to Esquelbecq, Roquetoire and Vincly (near Fruges), and the Divisions started training for the battle of Loos.

7. For the battle of Loos the 3rd Cavalry Division were placed at the disposal of the First Army. They proceeded to the Bois des Dames on September 20th, and the Field Squadron was employed on making cavalry tracks; on the 26th they assisted the 6th and 8th Cavalry Brigades to consolidate the position they had won on the east side of Loos, and were withdrawn on the 28th; Lieut. Pank was slightly wounded during the action. Meanwhile the Corps moved to Noeux le Mines for the battle; the 1st Cavalry Division reached Vaudricourt on the 25th and held and put in order the old German line behind Loos, afterwards working on the trenches under the XI. Corps, and being withdrawn on October 6th, the Field Squadron going to Serny, and on October 20th to Clarques; the 2nd Cavalry Division arrived in the neighbourhood of Ferfay on

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the 29th September, whence a dismounted party with the Field Squadron went up to Vermelles for work on the "O.G." Line until the 17th October, during which period Lieut. Latham, the Medical Officer, was mortally wounded Towards the end of October, work was commenced by dismounted parties from the Corps on a G.H.Q. line (the B.C.D.); the 1st Field Squadron were located at Abbaye de Woestin and worked on the Forêt de Clair Marais section; the 2nd Field Squadron at La Nieppe on the La Belle Hotesse-Wallon Cappel section; the 3rd Field Squadron at Lugy (near Fruges) on the Sempy section. This work was continued until the end of December, small parties working with Labour battalions being kept on until the middle of February, 1916; meanwhile the head-quarters of the Field Squadrons settled for the winter at Wierre au Bois (near Samer), Williametz and Coupelle Neuve, respectively. On December 31st, 1915, the Corps formed a Dismounted Division for work in the trenches; the composite Division proceeded to La Philosophe and worked on 2nd Line trenches in the Hohenzollern Redoubt, east of Vermelles, until its return to the Corps on February 15th, 1916; Major Johnson was appointed C.R.E., and Lieut. Grimsdale, Adjutant R.E. of the Division; during the period, Lieut. Pank (3rd Field Squadron) was wounded on January 22nd, 2nd Lieut. Chappell (3rd Field Squadron) was killed on February 3rd, Lieut. Greathead (1st Field Squadron) wounded on February 8th, Lieut. Wise slightly wounded and Lieut. Carnduff killed (both 2nd Field Squadron) early in January.

8. Towards the end of March, 1916, the British Cavalry Corps was broken up, the 1st Cavalry Division being allotted to the First Army, the 2nd to the Second Army and the 3rd held in G.H.Q. reserve, being later attached to General Gough's Reserve Corps. The 1st Field Squadron, at the end of March, sent up a detachment to Vedrel to work on the Estrée-Cauchie-Verdrel Line, under the IV. Corps, this work being continued until June 19th, when mounted training was carried out at Hardelot. On June 26th, the 1st Cavalry Division arrived at Querrieu for the Somme Offensive, the Field Squadron having to construct several bridges over the stream; during July they stood to and moved up on several occasions, and on July 24th proceeded dismounted to Fricourt for work with cavalry, on trenches at Montauban and Bernafay Wood, under the XIII. Corps; this work was continued until the formation of the cavalry Corps at the beginning of September, 1916. The 2nd Field Squadron moved on May 12th to Ledinghem, and at the end of May detachments were sent to work under the Canadian Corps at Abeele, and the V. Corps at Bailleul, while Lieut. Armstrong was sent to the Second Army School at Wisques as an instructor. In July the Squadron moved to Au Souverain and a party was sent to La Crèche to work with dismounted Cavalry on trenches concrete

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O.P.'s, etc., round Hill 63, until September, when the Division marched to near Querrieu to join the Cavalry Corps, the Field Squadron being sent on in advance to near Fricourt. The 3rd Field Squadron, during May and June, trained at Le Touquet and St. Riquier, and also worked on the G.H.Q. Line north of Fruges. On June 24th the Division marched to near Querrieu for the Somme offensive and the Squadron cut gaps in the wire west of Albert; on July 3rd they moved back to Hocquincourt, and to Vecquemont on the 8th; the Field Squadron was then employed till the end of the month on trench work with dismounted cavalry in front of Contalmaison and Mametz Wood, a track east of Le Carcaillot to south of Carnoy, water supply at Carnoy and roadwork east of Albert. In August they went to Le Quesnoy (west of Amiens) and a party was sent up to help the Divisional machine gunners in the Leipsig Redoubt; the Squadron moved on August 5th, to Dompierre, and another party was sent to Aveluy for work under the II. Corps, where Capt. Cobb and Lieut. Hay were wounded; on September 9th, the parties rejoined and the Division marched to Querrieu to join the Cavalry Corps.

B. THE INDIAN CAVALRY CORPS.

1. Before the war only one Field Troop (without horses) was maintained in India; this was the 1st Indian Field Troop with the 1st (K.G.O.) Sappers and Miners at Roorkee. A certain number of men of the 3rd Sappers and Miners had been trained in mounted duties, and equipment for a field troop was maintained at Kirkee.

2. The first cavalry to reach France from India was the Secunderabad Cavalry Brigade, who accompanied the Indian Infantry Corps and landed at Marseilles on September 27th, 1914. This brigade was accompanied by the 1st Indian Field Troop (Capt. R. C. R. Hill and Lieut. F. S. Collin) who had mobilised at Roorkee on August 8th, and left Bombay on September 3rd. The brigade concentrated at Orleans on October 7th, and reached Vieille Chapelle on November 1st, and were employed on trench work between Rouge Croix and Festubert until the end of December, under the Meerut and Lahore Divisions. The Field Troop was withdrawn to Basse Rue (near Berguette) on December 25th, and the Brigade then joined the Indian Cavalry Corps.

3. On November 7th, 1914, the 1st Indian Cavalry Division landed at Marseilles and concentrated at Orleans on November 15th. They were accompanied by the 2nd Indian Field Troop (Capt. E. K. Molesworth and Lieut. T. B. Harris) and consisted of men drawn from the 2nd (Q.V.O.) Sappers and Miners at Bangalore; the equipment had been obtained from the 3rd Sappers and Miners, and the men were mounted in Indian tongas belonging to the

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Gwalior Transport Corps. The Troop had mobilised at Bangalore on September 18th, and left Bombay on October 16th. In accordance with the Indian organisation, a C.R.E. with several Field and Assistant Field Engineers accompanied the Division (Col. C. E. Baddeley, Majors G. A. Leslie and A. G. Bremner, Captains A. R. C. Sanders and E. K. Squires and Lieut. A. A. Chase, Survey Officer). The Division reached Auchel on November 30th.

4. On December 14th, 1914, the 2nd Indian Cavalry Division (2 Brigades) landed at Marseilles, and concentrated at Orleans on December 22nd. No Field Troop accompanied the Division, but there was a C.R.E. and several Field and Assistant Field Officers (Engineers). (Lieut.-Col. H. J. Marshall, Major S. D'A. Crookshank, Captains D. Ogilvy and B. H. Fox). The Division reached Mametz (near Therouanne) on December 31st.

5. On the arrival of the 2nd Indian Cavalry Division it was decided to form an Indian Cavalry Corps, which assembled by the end of December, 1914, in the neighbourhood of Aire. The Secunderabad Cavalry Brigade, with the 1st Indian Field Troop, joined the 2nd Indian Cavalry Division.

6. On the formation of the Corps it was decided to abolish the Indian organisation of R.E. with Cavalry, and to adopt the British system. Accordingly the C.R.E.'s, Field and Assistant Field Engineers were dispersed and the formation of two Indian Field Squadrons put in hand, the drivers, equipment and wagons to come from England, the sappers from India. On December 14th, 1914, Capt. W. H. Evans and Lieut. Nosworthy were sent to Aldershot to collect the British contribution; they arrived in Rouen on December 24th, and joined the Indian Cavalry Corps at Clarques on January 2nd, 1915. It was found, however, that India was unable to supply any more sappers, and after some delay, Major W. H. Evans and Capt. B. H. Fox were sent to Aldershot on March 17th to collect, train and bring out British sappers and the remainder of the equipment; the detachments reached the Corps on May 10th and 17th, 1915, after which the formation of the 1st and 2nd Indian Field Squadrons at Wittes and Erny St. Julien was rapidly completed. (1st.—Majors A. G. Bremner and W. H. Evans, Capt. A. A. Chase and Lieut. H. G. Greswell). (2nd.—Major S. D'A. Crookshank, Capts. D. Ogilvy and B. H. Fox). The two Indian Field Troops stayed with the Corps until July, 1915, when they were broken up and sent to the Indian Infantry Corps.

7. The Canadian Cavalry Brigade came to France in May, 1915, as a dismounted unit attached to the Canadian Corps. They were joined early in October, 1915, by the Canadian Field Troop, also dismounted, which had been raised at Aldershot on September 1st, 1915, and consisted of British sappers (Capt. R. F. Mainguy, Lieut.

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S. F. C. Sweeney and 2nd-Lieut. O. R. Lyster). After being employed in the trenches about Kemmel Hill, under the Canadian Corps, they were sent to the 1st Indian Cavalry Division at the end of January, 1916, to train as cavalry, later being attached to the 2nd Indian Cavalry Division. In June, 1916, the Ambala Brigade of the 2nd Indian Cavalry Division, with a troop of the 2nd Indian Field Squadron, were sent to Mesopotamia and their places were taken by the Canadian Cavalry Brigade and the Canadian Field Troop. The Canadian Field Troop was, however, not finally merged into the 2nd Indian Field Squadron until January, 1917.

8. Apart from the Secunderabad Cavalry Brigade, the Indian Cavalry Corps did not come in contact with the enemy until January, 1915, when each Division in turn was put into the trenches at Festubert for a short period; the 1st Indian Field Troop remained up for some time, working under the 3rd Division. From February to the end of April, 1915, the Corps was employed on constructing G.H.Q. Defences in the neighbourhood of St. Venant and the Forêt De La Nieppe (H.Q., R.E., 1st Division, St. Hilaire and 2nd, Clarques). During the early part of 1915 the Corps moved up on several occasions in support of attacks, returning always to the Aire area; on March 11th to Auchel for the Neuve Chappelle battle; at the end of April into Belgium for the 1st Gas Attack at Ypres; on May 17th east of Lillers for the Festubert attack; on May 27th to Ypres for the 2nd Gas Attack (1st Division only). On the latter occasion the 1st Indian Cavalry Division were put in the trenches at Hooge and both the 1st Indian Field Squadron and 2nd Indian Field Troop did a good deal of front line work at Hooge and Railway Wood. (Capt. J. C. Wickham severely wounded). From the end of June to the end of July, 1915, dismounted men from the 1st and 2nd Divisions were employed on the reserve trenches and strong points in the Laventie (under the Indian Infantry Corps) and Noeux-Les-Mines (under the IV. Corps) areas, respectively.

9. On August 1st, 1915, the Corps, after concentrating in the Aire area, marched south to join the newly-formed Third Army in the Flixicourt area (Field Squadrons at Domart-en-Ponthieu and Belloy-sur-Somme). During August and September each Division in turn held a portion of the line at Thiepval, under the 51st Division, while dismounted parties also worked on reserve defences near Senlis under the X. Corps. On September 21st the Corps was inspected by Lord Kitchener, and on September 22nd moved into the Doulens area to stand by for the battle of Loos. On October 13th the Corps moved back into the Flixicourt area, shifting on the 22nd to the Hallencourt area (Squadrons at Liomer and Villeroy). And on December 16th to Gamaches area (Squadrons at Embreville and Villeroy). The Field Squadrons held trench warfare schools through-

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out the winter and a great deal of work had to be done on repairing roads. An emergency dismounted Division was formed on paper with the senior Field Squadron Commander (Major W. H. Evans) as C.R.E. From January to March, 1916, two dismounted digging parties, each with a dismounted Field Troop, were sent up from each Division to work on Corps defences in the Third Army area; instructors and men for work were also supplied to the Army School at Flixicourt. Towards the end of March the Indian Cavalry Corps was broken up. The 1st Indian Cavalry Division moved northwards to the Auxi-Le-Chateau area, where the Field Squadron was employed on the construction of the Third Army School at Auxi-Le-Chateau. The 2nd Indian Cavalry Division stayed in the Fourth Army area. Both Divisions were subsequently attached to General Gough's Reserve Corps.

10. The 1st Indian Cavalry Division remained in the Auxi-Le-Chateau area until May; special training was carried out on the St. Riquier training ground; the Field Squadron was employed on the construction of a Divisional School at Vacquerriette. On May 10th the Division moved to the area west of Avesnes-Le-Comte (Squadron at Leincourt), in close support of the infantry of the Third Army; Capt. R. S. Rait Kerr was left as instructor at the Third Army School, with a small detachment from the Field Squadron. A Divisional School was constructed at Givenchy-Le-Noble and a detachment was sent to Arras to work for the R.H.A. of the Division. On June 30th the Division marched to the Doulens area, ready for the Somme Battle, moving to the Auxi-Le-Chateau area on July 2nd, and to the Aubigny area (Squadron at Agnieres) on July 20th. The whole Field Squadron was employed under the XVII. Corps until the beginning of September, just north of Arras, on front line system redoubts, concrete field gun emplacements and dug-outs for Corps Heavy Artillery; Lieut. F. A. Farquharson was wounded slightly on August 27th. On September 3rd the Division marched to the St. Riquier area, and on September 13th reached the Allonville area near Querrieu, where they joined the newly-formed Cavalry Corps.

11. Except for a training period at St. Ricquier, the 2nd Indian Cavalry Division stayed in the Alloncourt area until July 1st, 1916, when they proceeded to Bussy-Les-Daours for the Somme offensive. The Field Squadron went on to Meaulte and later to Fricourt, and until the formation of the Cavalry Corps in September, 1916, was employed on helping their Division in attacks, making cavalry tracks, shifting guns in Mametz Wood and general trench work under the XIV. and XV. Corps.

(To be continued).

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GEOLOGY AS APPLIED TO MILITARY REQUIREMENTS.

Lecture delivered at the S.M.E., Chatham, by A. BEEBY THOMPSON, M.I.Mech.E., M.I.M.M., F.G.S., on 29th Oct., 1925.

THE incessant demands for increased supplies of water to comply with the more exacting conditions imposed by the medical profession and sanitary authorities, place upon the Engineers an increasing burden of responsibility. These demands are no less insistent in military than in civil circles, and in districts of congested population, low rainfall, or where the geological conditions are unfavourable, Nature unaided fails to satisfy needs; but whereas, under civil conditions years may often be occupied in detailed studies before embarking upon a scheme of supply, under military conditions it is often a question of days or even of hours.

The execution of emergency water supplies, such as are usually needed during a Military expedition, call for quick, confident, and perhaps, courageous decisions, and these cannot be made without a fair knowledge of the principles of geology and hydrography. To-night I propose, with your permission, to outline the principles which guide one in the search for supplies of water capable of quick development, neglecting the larger subject of water conservation or long distance transmission from available supplies.

The time factor usually precludes any detailed geological examination being carried out, but if topographical (contoured) or geological maps are available they will be found of great service and should at once be obtained. Without, however, any assistance from maps an engineer with geological instincts will quickly sum up the general situation from a hasty reconnaissance of the country. From the nature of the topography, scenery, vegetation, and rock fragments in river beds, an experienced observer will quickly acquaint himself with the main features of interest and direct his steps to the obvious spots of promise.

But, before proceeding further, it is proposed to discuss very briefly the progress of water from its precipitation onwards. Potable waters mainly owe their origin to the sea, which furnishes a practically limitless source of supply, forming as it does 75 per cent. of the earth's surface. By a series of complicated meteorological processes involving evaporation and air currents, set up chiefly by temperature differences, water vapour is carried in the atmosphere until it is confronted with conditions which cause its precipitation. When the atmosphere can no longer hold its charge of moisture at the

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temperature prevailing it is precipitated, either gently as mist or dew, or more violently thrown down as rain, snow, hail or sleet.

This water is not equally deposited on the earth's surface. Large portions of the earth are desert because rain rarely falls, but even in regions of good rainfall the amount of precipitation varies greatly within short distances. Hill ranges encourage rainfall by chilling moisture-laden air, and in the higher ranges, where the temperature is always low, the accumulated snows of winter form glaciers which are a perennial source of water and the main feeders of most great rivers of the World. It is the winter-accumulated snow and ice that furnishes the regular supplies of water for most of the great hydro-electric stations.

Being the condensed product of evaporation, water reaches the surface in a state of comparative purity, but during its descent it dissolves oxygen and carbon dioxide from the atmosphere, and this latter being an acid plays a very important part in subsequent events bearing upon economic water problems. Water is one of the most powerful solvents known, so that on coming into contact with the earth it quickly dissolves soluble substances which it may meet. The carbon dioxide in solution causes the water to attack limestones in particular, and in this way carves out passages and chambers in their midst which later become important reservoirs for water.

Having reached the surface, water is disposed of in three ways.

1. Surface run-off.
2. Evaporation and absorption by vegetation.
3. Percolation into the ground.

In temperate climates percolation, with which we are mainly concerned for ground water supplies, approximates 25% of the rainfall, run-off amounts to roughly another 25% whilst evaporation and vegetation account for about 50%.

Rainfall is fairly evenly distributed over the year in some temperate countries, but in others its fall may be confined to one or more brief periods of the year. In tropical and mid-continental countries there are generally defined seasonal rains, and so regular is their appearance, if not the amount of precipitation, that in some regions the exact date of the first rainfall of the season is repeated every year. An annual rainfall of between 20 and 40 inches per year, say 2,000 to 4,000 tons of water per acre, may be regarded as an average for most thickly populated fertile countries, but there are regions of no rainfall as well as regions of deluges. In one sector of Assam the rainfall averages over 400 inches (33.3 ft.) per annum. Rain may fall in gentle showers or in deluges, frequently or at long intervals, in hot or cool weather, on forested, cultivated or barren land, and the ratio of run-off to absorption is influenced by these

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factors. A fall at the rate of 1 inch per hour attracts attention, but falls of 4 inches to 8 inches per hour have been recorded, whilst rates up to 24 inches per hour have been measured for brief periods.

In many countries of temperate climate the summer rainfall has little or no influence upon ground water supplies, as most of the rainfall is dissipated by surface run-off, evaporation and consumption by vegetation. In this connection capillarity plays an important role, for until water passes below a certain depth it is subject to constant losses which vary with the local conditions of soil and climate.

Water reaching the earth flows over the surface, and if the rocks are porous a certain proportion is absorbed. Naturally the ratio of absorption to losses depends upon such factors as :—

a. The contours of the land.

b. Obstructions to the passage of water, such as vegetation, or surface irregularities.

c. Nature of the rocks.

d. Geological structure.

Were the whole land surface composed of an unbroken sheet of impervious rock all precipitated water would be quickly lost by run-off and other causes, but fortunately Nature introduces innumerable obstacles.

The first important point which I wish to emphasise is that, broadly speaking, the earth everywhere is water-saturated below a varying distance from the surface.

This level of saturation is known as the water-table. The water occurring below the water-table is, however, only stagnant in certain special cases, and the great mass of it is constantly, if slowly, flowing from higher to lower levels, often emerging as springs, and being replenished by upland rainfall, mist and dew.

Were the earth composed of uniform material, then the water-table, concentration, and flow of underground water would be a comparatively simple affair, and what we have to consider is the factors which modify its occurrence.

Most important of all are the properties of rock known as porosity and permeability.

Porosity may be defined as the ratio between air space and mineral matter in a given volume of dry rock, and therefore represents the relative amount of water which that rock can hold when saturated. Rocks vary enormously as regards their porosity, and although we are considering everything below the water level as saturated, the porosity in many cases is so low as to be negligible, and such rocks are to all intents and purposes dry. Examples of rocks of negligible porosity are illustrated by granite and, indeed, practically all igneous rocks, compact marbles, well-cemented sandstones, etc.;

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from these all gradations are found up to the highly porous beds such as loose sands, gravels, etc., where the porosity may approximate 30%.

Mere porosity, however, is not sufficient to ensure a supply of water, not only must the bed contain the water, but it must be able to give it up readily; in other words it must be permeable. Permeability is the property that allows a flow of water through the rock, and is dependent on the size of the pore spaces. A good water-yielding stratum or *aquifer* must, therefore, be both porous and permeable. To make the difference between these two properties quite clear, consider a substance like clay. That dry clay is highly porous is obvious from the way that it will absorb water, in fact, many clays have a porosity as high as 50%.

Wet clay does not, however, give up its water readily, and can be used as a waterproof material, as in the "puddling" of earth storage tanks, etc. Clay, therefore, has a high porosity but a low permeability, and is useless as a water yielding stratum, indeed, it forms, when moist, just as effective a barrier to the passage of water as a non-porous rock such as granite.

The porosity and permeability of rocks has, therefore, a very important bearing on the water-table. In homogeneous, porous rocks, in countries of moderate rainfall, the water table tends more or less to follow the contour of the ground, but with a less accentuated form; that is, the contours of the water table flatten out and become less marked as sea level is approached, till the two surfaces, that of the ground and that of the water table, approximate at sea level.

As, however, the earth is composed of rocks of very varying porosity and permeability, many factors enter to modify the water table. Where, for example, an impervious bed interrupts the seaward flow of the underground water, the water table may reach the surface and a spring results, and the vast majority of springs will be found to be located at the junction of pervious and impervious beds.

Just as the visible flow of water in a river is confined to a certain channel by its banks, so the underground flow of water is controlled by the arrangements of pervious and impervious beds. This feature taken in conjunction with simple hydrostatic laws constitutes the basis of water finding.

Underground supplies of water may be roughly divided into two classes, those obtained from recent deposits, such as river valley deposits, delta deposits, etc., and those drawn from solid formations, sandstone, limestone, etc. I propose to deal mainly with the first, on account of their importance in giving quick emergency supplies.

In considering valley deposits it is simplest, though not strictly accurate, to imagine the valley sides and floor as being of solid rock

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and more or less impervious, either on account of actual imperviousness or on account of being already saturated with water.

Actually, taking the whole drainage area of a river system, the visible flow of the river and its tributaries may be regarded merely as the surplus water in the great never-ending cycle comprising evaporation from the ocean, transport by wind and formation of clouds, precipitation as rain and return by gravity flow to the ocean. In drier climates the same great cycle of events is taking place, but with the exception of occasional floods the whole of the gravity flow to the ocean may take place below ground. In hundreds and thousands of desert and semi-desert parched and arid valleys, without a drop of visible water, but with the bones of animals killed by drought, this slow silent flow of water seaward is taking place only a few feet below the surface. The simplest and yet most striking illustration of this is to be found in many valleys in semi-desert countries, where great expanses of valley gravels are interrupted by rocky barriers which form narrow gorges. In each of these gorges there may be a considerable surface stream, but below the gorge this sinks below the surface and leaves an absolutely dry water course only used by flood waters; the next gorge down stream, however, again restricts the area of flow and so raises the water table to the surface, and a visible stream results.

The great value of the underground flow of water lies in the fact that it is infinitely slower than the surface flow, thereby leading to the conservation of great volumes of water. If we imagine a river system carved out of wholly impervious rock and with no surface soil or gravels, then the effect of rainfall would be temporarily a great flood and then a dry water course, which is, in effect, what happens to the visible water in semi-desert regions.

In nature, however, a considerable portion of the rainfall is taken up by porous beds, and so slow is the flow of water through these that they act much as a reservoir, and tide over the periods of drought between the occasional heavy rains, the only effect of a prolonged period of drought being a certain lowering of the water table in the valley deposits.

With regard to these valley deposits themselves, they vary greatly, as an inspection of any river valley will show. Gravels, sands and clays (muds) alternate and replace each other in what appears at first sight hopeless confusion. Some gravel beds are cemented with clay or lime, and will not yield water although well below the water table of the valley. If, however, the bed of a winding river course is examined, certain definite features will be noticed that influence subsoil flows. On the convex curve where the current is strongest we shall find only the coarsest material, the fine sand or mud being swept along till it comes to rest in quieter

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water, generally in the concave curve. As in course of ages river erosion causes a snake-like movement of the curves down stream, it is easily understandable how this alternation of types occurs. In locating wells in valley deposits the important points are therefore to try and select sites (1) where the water will naturally tend to collect (2) where the coarser deposits of old channels are likely to be struck. With regard to (1), we must try to picture the valley stripped of its recent deposits and, remembering that even underground water is always trying to find a lower level, endeavour to reason out where the underground flow is most likely to be. Picture, for example, a wide dry watercourse, half a mile or so across, flanked on one side by gently rising ground, and on the other by a steep hillside. The probability—though there is no absolute certainty—is that the valley, stripped of its deposits, would continue the general slope of the two sides, so that its deepest point would not be in the centre of the present dry water course, but close up to the steeper side, where probably the best water supplies would be obtained. Again, when such a valley narrows to a gorge through more impervious rock, there is likely to be a ponding back of the underground water, so that copious supplies may be expected at such a location. Again in such valleys old river terraces often give a clue as to former river channels and thus afford a guide to the probable location of coarse gravels and sands.

River courses present varied and peculiar features, which must be considered before determining a course of action. The nature of their beds depends upon the character of the rocks composing the drainage area. They may have a gentle or steep gradient, and the material composing their beds may be sands, gravels, rubble or boulders, or mixtures of any of these. Usually the upper reaches of river courses contain coarser material than the lower sections when sea level is approached or the gradient flattens; in gorges the material is coarser than in wide flats, and in most cases there are alternations of fine and coarse detrital material through which water percolates at variable speeds if below the water table. These detrital deposits are composed of the more or less rounded fragments of the rocks of the district, and when limestones are prevalent the material may be mainly calcareous, otherwise the sands and gravels are generally mostly silica or fragments of igneous rocks.

In some cases the fragmentary beds become cemented with lime and converted into a conglomerate impervious to water, at other times coarse gravel may be so tightly cemented with clay as to be impervious to water, but generally there are intervening layers of uncemented material which carry water.

Some sluggish running streams meandering over wide flat plains have mainly silty beds which yield no economically valuable supplies of water, but even amidst such surroundings it may be possible to

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pick up sandy strips, often indicated on the surface, representing ancient river courses.

These latter conditions are exceptional rather than general, and in the majority of cases valleys carrying the drainage of a large catchment area contain an abundance of permeable beds capable of yielding copious supplies of water.

When selecting a site for a water well the valley gradient should be carefully observed. Any elevation of the water table should be noted, or if water is forced to the surface by a contraction of the channel or other obstruction, a site should be selected upstream rather than downstream, where water often follows narrow channels less easy to pick up.

Along many narrow river courses in hilly or rocky country there are considerable variations of the gradient, and water may be periodically raised to the surface along a reach of some distance.

Whether there is surface flow or not, there is always some subsoil movement of water in valleys of any importance, and what I wish to emphasise is the fact that these lower waters are usually quite isolated from the upper, and so preserved from contamination with surface or upper water to which rain can carry pollution direct from the surface.

Obviously all ground waters were once surface waters, but in most cases the percolated water enters beds at an elevation and at a distance from habitations, also the water is subjected to a slow process of filtration and perhaps aeration, which ensures its purification. That these lower waters are commonly effectively isolated from the upper waters is proved by the variable static level of waters struck in different acquifers of a series of valley sediments. Rarely is a series of sediments homogeneous. Water is found to enter a driven tube well at different depths, between which little or no water is found. The water level of deeper acquifers may be higher or lower than the upper. In those cases where the downstream flow is restricted and the point of admission far upstream, the static level is higher with depth. On the other hand, where a very permeable bed underlies less permeable deposits, the water may have a lower static level.

In both cases isolation from surface pollution is assured, and if the water fails to satisfy the chemists it must be due to peculiar circumstances needing investigation.

Another characteristic which proves that these valley sediment waters are separated from each other is the occasional variable quality of the water. In regions, particularly where the rainfall is low and sporadic, the waters at different levels show variable mineral contents in solution. Lower waters may be more or less mineralised than upper according to the circumstances. Sometimes a big rise of water table due to an exceptionally heavy rainy season may cause

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all the upper waters to be undrinkable, whilst the lower remain unaffected. This is due to leaching of salts from gravels which have for a long period been left untouched by water.

When rivers discharge into the sea or into large lakes a fan-shaped delta is usually developed. Unless the currents are strong, silts may predominate, but generally such silty deltaic deposits contain lenticles of sand which yield water freely when struck. The sands are often much finer in grain than further up-stream, and sometimes it is difficult to obtain useful supplies of water without drawing in much sand.

The reason for stressing the value of river valleys as sources of water supply, it will be gathered, is due to the ease and speed with which acquifers can be reached and water made available. As a rule, driven tube wells can be employed as the sediments are generally unsolidated and the water table is within 20 ft. of the surface. That tube wells are not toys was demonstrated by results in the war, but the extent to which they could be used was a revelation to me and to others. By no other method could supplies of good water be rendered available at short notice. Shafts sunk into these valley deposits are generally unsatisfactory, for they need lining; the sand constantly runs in and requires cleaning out, and it is impossible, without special plant, to proceed deeper than the first water, which it is always preferable to avoid.

Apart from pronounced river courses and deltas there are other locations where recent sandy deposits can be explored for water. Thus the sandy fans of detritus from mountain valleys—the results of storms—may be followed to a point below the water table of the valley, in which case copious supplies of good water may be made available. Such deposits were successfully developed by tube wells on the Struma plains near Monastir, during the war.

There are frequently strips of coastline along which sandy sediments, composed of land wash and beach sand and gravels, have grown, forming admirable reservoirs for rain water. Admitted water washes out the salt and holds back the sea water, so that unless drawn too rapidly good water can be obtained at about sea level for long intervals between rains. Coastal sand dunes may be a source of good water along some shores where rainfall is low.

An obvious and easily developed source of supply is from springs, which often yield a water of high purity. Such salts as they contain are rarely injurious to health. Springs usually appear at the junction of an impervious bed and an acquifer on a sloping hillside when the continuity of the strata is broken by a valley. Water may ooze along a long strip of country which becomes boggy or issue from a few more or less separated spots, where the water concentrates due to some local peculiarity. Trenches can be dug along the outcrops to lead away the water. In limestone districts

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water tends to carve out by solution definite passages, so that large concentrated bodies of water emerge from the ground at low points. Springs of this nature reach enormous volumes at times, forming indeed rivers both in the ground and on their exit. Such are naturally comparatively rare, and the usual spring met with may yield a few hundred to a few thousand gallons hourly. As the yield of the usual type of spring falls off rapidly with the advance of the dry—usually summer—season a careful record of performance should be kept so that future yields can be approximately predicted.

Turning now to water supplies from the solid strata much more attention must be paid to the geology of the district. Here again the underlying principle is that underground water is always trying to find its way to lower levels, but its course is profoundly modified by the distribution of pervious and impervious beds so that in dealing with the older and more consolidated sedimentary beds, more difficult water problems are met with. It is rarely possible to reach useful aquifers without sinking shafts or drilling wells and the water table is usually below 30ft. from the surface, thus preventing the use of surface suction pumps.

In nearly all cases, water gains access to the porous beds, such as sandstones, limestones, etc., along their outcrops, and such outcrops vary in form according to the thickness, dip and strike of the bed and the topographic form of the surface. In many cases the higher inland areas, where rainfall is greatest, are composed of the least porous rocks so that much of the precipitation is carried off by surface rivers and streams. These latter cross the outcrop of porous beds into which part of their water constantly passes. A stream in its winding course may cross and recross the outcrop of a porous bed many times, thus giving numerous points of infiltration. Vegetation, such as forests or moorland heather and moss, play an important part in impeding run off and so increasing the amount of infiltration into porous beds. To deduce the subsequent underground flow of the water, a knowledge of the geological structure of the district is essential. Water will naturally tend to collect where the strata have been folded into synclines and basins, though the faulting of a porous dipping bed against an impervious clay will give the same result.

A hasty survey of the district will generally disclose the main geological features. The direction of dip and nature of the sediments can generally be ascertained by visits to all outcrops, and especially in water courses which cut through any surface soils. A visit to any nearby hills may also prove very useful. From the contours of the country one is able to judge of the extent to which any water-bearing stratum would be drained by the valleys or water courses, and the character of the sediments determines their probable value as water yielders. An unbroken succession of clays or shales

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is one of the most unpromising features to be met with. If, however, there are moderately thick beds of interposed sandstones, sands, gravels or limestones in the series, there is every chance of obtaining water when they are struck below the water table of the district.

These more compacted and cemented beds yield water far less freely than alluvial deposits. Usually water movements are more closely connected with fissure systems than porosity, but occasionally free yielding loose sands are encountered, when their capacity depends on their coarseness, thickness and continuity. Generally, water issues from a series of joint cracks and fissures such as nearly always break the homogeneity of the rock. This causes somewhat uncertain yields, but if a main fissure system be penetrated a well of large capacity may result. The firing of a shot may improve matters in some hard rocks. Supplies from chalk are mainly derived from fissures and flint beds, for although highly porous, chalk is not very permeable.

For the above reasons large yields must not be anticipated as a rule from boreholes of moderate depth and diameter. Under such conditions as described, important volumes of water could only be obtained by the lengthy operation of sinking large diameter shafts and driving headings along main fissured systems. At times, however, very free-yielding acquifers are struck by boreholes which give natural flows or pumping outputs of from 5,000 to 25,000 gallons per hour. I am here referring to wells of moderate depth, say within 500 ft. From deeper sources much larger yields may often be obtained, owing to the high pressure under which the water occurs. Two exceptionally large producing boreholes were finished in the Salonika area during the war. In one case the large supplies were obtained from the decomposed surface of the metamorphic rocks underlying a fair thickness of clays and sands. The other well was completed in a coarse gravel at the junction of the sedimentaries and the older metamorphic rocks. These wells were never tested to their full capacity, but were capable of very large outputs. As a rule, yields in excess of from 1,000 to 2,000 gals. per hour cannot be anticipated from wells of 6 to 8 in. diameter within a depth of, say, 500 ft.

Artesian wells—that is, naturally flowing wells—are only obtained under certain geological conditions. In large basins surrounded by high ground deep-seated acquifers, protected by a thick impervious covering, may hold water under high pressure. Theoretically the water in such a basin or trough should acquire a pressure equal to the head created by the water table in the hills where the water finds admission. This pressure is often approximated, and if the permeable stratum is struck, large natural flows of water result, or if the well is capped a high pressure is registered. This

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is the text-book type of artesian structure, but there are other and more frequent circumstances which result in artesian flows.

Flowing water may result from drilling on gently sloping flanks of hills where porous outcropping beds are lenticular, thus preventing the free escape of admitted water. When penetrated at a spot far below the level of the outcrop, the enclosed water may be under a considerable head. Many such wells were struck when drilling in the tertiary sediments flanking the hills near the Salonika base.

Natural flows are frequently struck in deltas or estuaries and along littorals, where both the water table and land surface approximate sea level. In these cases flows usually result from the difference in gravity between sea and fresh water. Sea water, owing to its higher density, will support a higher column of fresh water. The difference of about 2% in the weight of fresh and sea water creates a static head at sea level, even when there is no appreciable frictional resistance to its seaward movement; consequently, if a very permeable bed is struck large flows of water may be obtained. Salonika city supply was obtained from wells of this type, when, however, the acquifer was composed of fine and loose sands which could only be kept stabilised by the most careful adjustment of flow.

An engineer called upon to provide water supplies in a new area should form his opinion on the following points:—

The amount and distribution of rainfall in the region.

The extent and character of the water-sheds (catchment) draining into the zone of occupation.

The topography of the region. Relative elevation, and particularly the drainage system.

The nature of the rocks of the area. Old or new, metamorphic, igneous or sedimentary, whether argillaceous, arenaceous or calcareous.

The main character of the river courses (whether clay, sandy, limey, coarse rubble, gravel or fine sand).

The nature of any springs.

From a brief critical survey a keen observer will have decided where he can most quickly tap supplies of water. He will know roughly the kind of water he is likely to find, and he will have formed a very fair idea concerning the permanence of supply at various parts of the region. The unpromising areas will have been noticed.

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ENGINEERS AND THE ARMY.

By MAJOR-GENERAL G. WALKER, C.B., C.B.E., D.S.O.

On the 7th October last, Major-General H. F. Thuillier delivered an invaluable lecture on the above subject, at the Royal United Service Institution. In the course of the lecture General Thuillier traced the history of the "Ordnance" Corps, as the Royal Artillery and Royal Engineers used to be called, and showed how a good many of the difficulties which Royal Engineers have to contend with are directly traceable to the anomalous position in which the Corps was formerly placed in relation to the rest of the Army. I do not propose to follow the lecture in detail, but to take as texts for this article certain plain difficulties which we have to face at present and which are clearly brought out in the lecture and the discussion which followed it. In considering these, my object is to try and show what we, as Royal Engineers, can do to overcome the difficulties, quite apart from any possible changes that might be made in the Service regulations.

2. To facilitate matters, I shall tabulate certain statements taken from the lecture and the discussion and consider each separately. The statements will unfortunately be divorced from their context, but everybody can read the context for themselves in the Journal of the R.U.S.I. What I am going to say may sound egotistical, but it is the result of my own experience in the Corps over a period of a good many years, and whether the writing may seem egotistical or not, it is at any rate an effort to put before my brother officers the methods which I have found helpful in overcoming the difficulties.

I may say at once that I am not going to discuss Regulations, Establishments or Army Policy. That is not our office. Our business is to devise means to make the Engineer Arm efficient, under the existing rules, whatever they may be.

3. The statements I propose to discuss are as follows. They are paraphrases not textual quotations.

I. Taken from the lecture.

(a) Various branches of the Army are brought up and trained in watertight compartments. We have a mentally partisan outlook before we really become soldiers. *Esprit de Corps* is good, but if it tends to make us disdain and neglect the study of the work of other branches it becomes an evil.

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II. From the Discussion.

(a) An officer of Infantry at a large military station states that on only two occasions has a R.E. officer been attached to his unit.

(b) There is a practical difficulty in training R.E. officers in matters military, in consequence of the fact that we have 1,000 officers and only 12 field units. The work a sapper has to do on manœuvres is more or less imaginary.

(c) The Engineer in Chief and Chief Engineers of Armies must be not only skilled engineers but skilled soldiers.

(d) I should like the regulations to require that the Engineer in Chief should dine and drink a glass of port with his Chief of Staff as frequently as possible.

(e) I would impress on you the importance of an engineer officer possessing a Staff College certificate. The Corps should have men of strong personality, supported by sound technical knowledge and wide military experience, to fill high engineering posts in the field.

(f) One of the most difficult questions facing us at present is the military education of the Royal Engineer officer. Our great difficulty when we want to attach R.E. Officers to other units is to devise means whereby they can be spared from barrack work.

4. The above is rather a formidable looking list of difficulties, but given good will and a determination to succeed, none of them are insuperable. I shall now proceed to discuss them seriatim.

I. (a) Specialised training, at first, is essential for an engineer. At the same time the spirit in which the training is administered by instructors is all important. The young Royal Engineer is rightly taught to be a soldier first and then to be an engineer. If the instructor will inculcate the principle that the pupil is learning to be a soldier in order that he may face the music alongside other soldiers, and that he is learning to be an engineer in order that he may supply the wants of other soldiers, the novice will get a just appreciation of his position in the military world. This is, I know, done nowadays, but I can testify that it was not always so. The young officer must have *Esprit de Corps*, but it must be of such a nature that it will make him realise that the honour of his Corps and his own personal honour also, depend and depend alone on their usefulness to other people. I have never known a case in which a useful R.E. Officer or a useful R.E. unit was overlooked or slighted by other people. Self-respecting humility and humanity are the things that are worth while. Self-praise never did any one any good. I know that when I left the S.M.E. and went into

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the Army, I was astonished to find how small a place the engineers filled in comparison with my estimation of their value. Those were days when *Esprit de Corps* was very narrow. In fact, I have heard my fellows say that other people knew nothing and did nothing. The real truth was that these critics never tried to find out what others either knew or did, and it was the critics who were the really ignorant. The cure is for the instructor first to impress the pupil, and then for the pupil, as soon as he gets the chance, to mix as much as possible with officers of other arms, play games with them, dine with them and discuss things with them. He must try to learn their point of view and then apply all his energy to helping them, whether in the field or in barracks.

II (a) (f) These two items have produced in the past the greatest difficulties for R.E. Commanders. The difficulties have, I think, arisen from two causes. Firstly, from a rather unbalanced zeal in R.E. Commanders to have their own job *of the moment* perfectly done, and secondly, from a lack of appreciation of the fact that their job of the moment is not their whole duty. I know quite well that I shall have people saying that I don't realise the difficulties of barrack work. Its intricacies, its grinding labour, its financial pit-falls, etc., etc. If I don't I ought to know, none better, and I am sure I do know. At the same time I know also that some people sit in offices too long, some people like an office; everything is to hand, and the routine of a well-run office is regular and not upsetting. These people get into a groove and *forget* that this work which they are doing in peace is the only present method of keeping their professional engineer attainments bright and up to the mark, and that it is not the reason for which they exist. War is what they exist for, not peace and, if they neglect their training for war they are neglecting their duty. Now how are they to do it? In every well-run C.R.E.'s District there is time for reasonable leave. In any District where this essential is not arranged for there is something the matter. Again, there is no question but that people go sick occasionally. In both these cases someone has to work "double tides." It is unfortunate, but it is true. The C.R.E. has to make arrangements, and he does it. I believe, in fact I know, that it will not stretch a C.R.E. too much to make the necessary arrangements also for the military training of his works officers. In some places he can swap them over with unit officers for a bit, but, apart from this, if he will set himself down *early in the year* to make out a programme by which military training and leave shall be arranged for, he can generally do it easily.

The training cannot be on ambitious lines, but an officer can go to a battalion for battalion training for a bit, or go as liaison officer with a brigade for brigade training, and so on. It can be arranged if it is tackled, even if it means that a foreman of works has to do

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e D.O's. job for a bit. Frankly, it is better to let the M.F.W. carry
—in fact anything is better—than that the R.E. officer should not
e trained, and systematically trained, year by year, in the military
de of his work. Theoretical military training, lectures, &c.,
n all be done in the winter. This can be arranged with the Staff
the Command, Division or Area. I know they are only too glad
help. In this connection it should be stated that G.O.C's. have
report on the military attainments of R.E. officers and are always
t to help them to improve them. It is for us to see that the answer
not that "we have no time." Briefly, then, it appears to me that
e R.E. officer can get a good deal of military training but that it
ans that R.E. Commanders must arrange it to a programme.

(b) This is dealt with above to a very large extent. At the same
me a great deal more can be done by arranging that officers do
t serve too long either on works or in field units. The idea that
officer must be always "Works" or always "Field Company" is a
icked one. We must get a reasonably constant flow of officers
tween the two classes of work. Our officers must all have a wide
perience of their duties.

As regards the sapper work on manœuvres—we all know that, *ethically*, it is of small value. On the other hand manœuvres
ally teach more to the Staff, as regards handling formations,
an anything else, and the R.E. unit commanders and officers
arn how to move with other troops and get an insight into the
ethods of handling large formations which they would not get
herwise. Further, even if no work is actually done, the R.E.
fficers and N.C.O.'s can work out a good many new and emergency
roblems as regards reconnaissance and organisation that the routine
ld works course can never present. Lastly, it is of the utmost
rvice to all concerned to realise that, when there is no work for
e sapper to do in war (it will seldom happen) it is a very good thing
o let him do *nothing*. I have known some very good sappers to
et killed because this point of view did not strike their superiors.
n fact, I have been uncomfortably near it myself.

(c) (e) The Staff College is a thorny question for us. We have
w vacancies and the competition for them is great. If we had more
e should be much better off, as every one who can should go to the
taff College. Still, we are dealing with things as they are. How
an we make the present rules help us more?

At present an officer who goes to the Staff College is inclined to
ope that he is going to better himself and never be a D.O. again. It
only human nature that he should do so, but it is the wrong point
f view to take up. I have known officers, on the other hand, who have
ed to get back to regimental work for a time, in order to keep their
and in, and who have not been able to do so. Valuing the staff
ollege training as I do, I should like to see Staff College graduates

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clamouring to get back to Corps work for a time; not necessar for their own advantage but in order that they may be able disseminate the Staff College point of view amongst their brot officers. Let us imagine how helpful it would be, in training wo officers, if one at least of them had been to the Staff College. would be child's play to him to do it and it would be invalua to the others. In my experience I have known this done by c officer under my own command with great advantage to hims and to other people. In my view every officer who has pass the Staff College should regard himself as an apostle of the St College teaching. We engineers, especially, require this teachi as, without it, we are much handicapped in our efforts to app our technical knowledge to the requirements of the Army. R officers have now far greater opportunities than ever before acquiring sound technical knowledge, but if we are to produ officers for the high engineering posts in the field, who have wi military knowledge, it is essential that those who go to the St College should not be cut off entirely from the technical side of t work of their Corps, and also that they should, as far as in the lies, endeavour to pass on the knowledge they have acquired the Staff College to their less fortunate brethren.

Personality is dealt with under the next heading.

(d) Here we are brought face to face with the human side of t problem. It has been said that "sappers" are all either ma married or Methodists. It was rather a cruel jest, and must ha been made by some one who had been stung by the aloofness of son ancient "sapper." However, it is an expression that is sometim heard even now, so we will consider it in detail.

First, let us take the "madmen." We all know that it is one the weaknesses of scientific souls to be inclined to bury themselv in their science. They are full of it and find it hard to prevent from interfering with their dealings with other men. The sold scientist must beware of this failing. By virtue of his adopt profession his first duty is to deal, and deal kindly, with other me His science must not be allowed to puff him up. Other men m not be scientific in his sense of the word, but they have attainmer of which he knows nothing. The scientific recluse is of no use an army in the field.

As regards the "married"—well, I think this is pure jest possibly the remark was made by one whom people would r marry. At the same time we are a married Corps, and, being suc we must see to it that marriage does not prevent us mixing wi other people. It really ought to help us to get to know people.

As regards the Methodism. This is a difficult subject to wr about. We all know, however, that there are such people as religio

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recluses. A man's religious views are his own business, but we have the authority of the best of books for saying that religion must not prevent a man mixing with his fellows. He must live in the world but not be of the world. Again, there is the question of duty. Duty to the Service, duty to one's fellow men. Nothing is, I think, more inspiring than to see the way a really religious man does his work and influences all those, with whom he comes in contact, for good. You can't do this by being a recluse.

Now we come to the question of dining and drinking port. We Englishmen do most of our real business to the accompaniment of eating and drinking. It may be foolish, but it's our way and it's a way of very old standing, in fact, it's part of our nature. I hold no brief for port drinking, though I am fond of it myself. I know, on the other hand, that some people don't like it and that with others it does not agree. The kernel of the question is, however, that, whatever you elect to drink, *don't drink it alone*. Share your pleasure with other people and try and share their troubles also. Remember that troubles shared are troubles halved.

Lastly, what about personality, what does it mean in this relationship? Every man has some personality born in him, some nice, some the reverse. I take it, however, that the personality required by the soldier means that he shall be imbued most strongly with a sense of duty; that he shall count himself as nothing in comparison with his duty; that he shall be firm in Council; that he shall be kindly and humane in his dealings with all men, and that, finally, he shall believe that, as he is trying to do his best for every one, they, in their turn, are doing their best for him. That is the spirit that makes men follow you and believe in you, and want your help and advice.

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CONSTRUCTION OF BASINGSTOKE MANŒUVRE CAM

By MAJOR A. V. T. WAKELY, M.C., *p.s.c.*, R.E.

INTRODUCTION.

Some apology is needed for the insertion in the *Royal Engine Journal* of a description of such a simple work as the construct of a Camp for an Infantry Brigade. It is work which ma hundreds of R.E. Officers have done before. Thousands of drawir and estimates of materials must have been made, used, and th filed away for future reference.

Nevertheless, when the present writer was instructed to prepa designs and estimates for a camp for the 4th Guards Brigac he could find none of these drawings and he had to start with blank sheet of paper. This wasted much valuable time, whi could have been available for unit training, and, owing to t speed at which the work had to be done, it must be admitted th strict economy in design did not receive as much attention as deserves. It is thought that the pages of the *Royal Engine Journal* offer the best opportunity for providing R.E. Office generally with an outline to work upon should they at any futu date be faced with a similar problem. It is not argued that tl designs submitted in this article are the best possible, they cou be improved upon in many respects. Those officers, howeve who have neither the time nor the inclination to work out a pla for themselves will find below designs and a scheme of work whi operated with success at Basingstoke.

STRENGTHS AND SCALE OF CAMP ACCESSORIES.

2. The camp was erected on Basingstoke Common t accommodate the 4th Guards Brigade and attached troops, a tot strength of 140 officers, 3,200 O.R.'s and 600 horses. The uni are shown in Appendix 2.

The layout was made out in May, 1925, by the Staff Captai 4th Guards Brigade and the O.C. 11th Field Coy. R.E. It wa submitted for approval to G.O.C., London District, and D.D.M.S Aldershot Command. The areas allotted to units are shown i Appendix 4.

The scale of camp accessories to be constructed by R.E. was lai down by Command for all camps, and is shewn in Appendix 1 The following remarks on this scale suggest themselves as th result of experience at Basingstoke :—

(*a*) Scale of ablution benches should be increased to 1-ft run of bench per 10 men.

(*b*) Duckboards at the scale of 20 per battalion should b provided for general use in the camp.

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(*c*) Officers' latrines should be at the rate of one seat per four officers.

(*d*) Showers or "Bains Douches" are better than 2,300-gallon tanks for bathing purposes.

SUPPLY OF MATERIALS.

3. A list of the stores required was made out at the end of May by O.C., 11th Field Co., R.E., on the forms shown in Appendices 2 and 3. The figures (not shown) for Appendix 3 are merely the number of articles (Appendix 2) multiplied by the amount of material shown in Appendix 5. In making out this list an allowance of about 10 per cent. should be made for contingencies. After the camp is occupied there are generally many demands, more or less justified, made by units. There is also maintenance and repair work. These necessitate a small reserve apart from the C.R.E.'s reserve mentioned below.

The stores were ordered by C.R.E. 2nd Division for all camps. The C.R.E. kept a reserve in his own hand for emergencies. This system worked well; it is better than if Field Company Commanders ordered their own stores. Part of the C.R.E.'s reserve was required in the case of Basingstoke, since two extra units were put into this camp after the stores had been ordered. It is suggested that Field Company Commanders should be allotted a small sum (say, £10) for local purchase of urgent stores which cannot be foreseen, *e.g.*, tow, wire, nails, etc.; this would save time and money when the camps are at a distance from Aldershot.

The C.R.E. ordered the bulk of the stores, except water supply stores, to be delivered at Aldershot, whence they were transported by lorry to Basingstoke on 17th and 18th July. The lorries worked to a schedule made out by 2nd Division. The tonnage moved was 90 tons. It is absolutely necessary to work the transport to a time schedule, otherwise there is great confusion and no certainty of supply. The arrangements made in this case worked extremely well. Water supply stores having been ordered from Messrs. Ockenden and Smith were delivered at Basingstoke Station. They were brought to the site by Field Company transport, five G.S. wagons having been provided for this purpose and for general work in the camp.

MANUFACTURE.

4. The 11th Field Coy. R.E. moved to Basingstoke on 17th July, and immediately proceeded with the manufacture of camp accessories.

There are two methods of manufacture:—

(1) To bring out all raw material to the camp, manufacture the articles required, and then proceed with erection.

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(2) To make all the articles under Divisional arrangements before going out, then transport the made articles to the site.

The first method is preferable, since it allows a certain latitude for emergencies. Also the lorries required for the transport of the manufactured articles are about double the number required for the raw material. It was found at Basingstoke that it was not possible to make out an accurate list of the number of articles required, owing to unavoidable changes in the layout of the camp and in the units to be accommodated. Appendix 2 shows what was eventually provided, but this list is about 10 per cent. more in total than the original list made in May, 1925.

ORGANISATION OF COMPANY.

5. The organisation of the Company for the construction of the camp was as under :—

Trade.	No.	N.C.O.i/c.	General Nature of Work.
Carpenters & Joiners.	12	1 Sergt.	Manufacture and erection of cook shelters, latrines, etc.
Sawyers.	2	—	Erection and working Saw Bench.
Electricians	2	—	Erecting Electric Light and Power.
Plumbers.	15	1 Sergt.	Water Supply.
Pioneer Carpenters.	10	1 Sergt.	Erecting stands for water points.
Unskilled Labour (1)	10	Inf. Cpl.	Digging trenches for water supply.
,, (2)	10	Ditto.	Digging holes for uprights, etc.

It will be noted that the section organisation of the Field Company was broken up for this work. This is necessary since the tradesmen must be grouped by trades. It is better and tends to quicker work to form these groups at the beginning, and to keep the same men on the same work. With this organisation the camp was constructed in 20 working days. It was finished on 15th August, the whole company having been taken for field works on four days during the period 20th July to 15th August.

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METHOD OF MANUFACTURE—CARPENTERS' WORK.

6. The following is a brief description of the general method of manufacture organised on factory lines for turning out cook shelters, latrines and all carpenters' work.

(1) The layout of the dump when stores arrive should be such that there is room opposite the stack of each size of timber to cut timber to length and to construct the shelters, etc. In photo No. 2 four stacks can be seen, 3-in. × 2-in., 6-in. × 1-in., 3-in × 1-in. and 9-in. × 1-in. This system avoids long carries and consequent waste of time.

(2) Opposite each of these stacks a bench (see (*a*) Photo 2), for cutting timber to length, is made.

(3) Having made a list of the lengths of timber required for each article, three men are put to work at each bench and they cut the total number of each length required.

(4) Templates are then made as under :—

Cook shelters and officers' latrines—2 templates each, one for each gable end.

Ablution bench—one template for framing.

Latrines and grease traps—one set complete as a sample.

These are made under the careful supervision of the senior N.C.O. Carpenter.

(5) Two men then work on each template and construct the number of each article required.

ERECTION.

7. For small cook shelters, of which there were a large number, a plan template carefully squared was made for erection purposes. One point was fixed on the ground in accordance with the layout of the camp. The advantage of a template is that unskilled labour can be put on to dig the holes for the posts without supervision of officers and senior N.C.O.'s. Templates were also made for the latrines showing the exact position of the pits. These templates were of great value since a large number of men can be put on to dig holes quickly without elaborate measurements.

DESIGN OF CAMP ACCESSORIES.

8. The design of each article is shown in the photographs; the amount of material required for each is given in Appendix V.

The following remarks on these designs are based on the experience gained at Basingstoke :—

(*a*) *Cooks' Shelters.*—Wire stays are required unless the shelter is firmly fixed to 4-in × 3-in. piles in the ground. The stays are quicker to put up.

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(*b*) *Meat Safes.*—Muslin is very unsatisfactory as a covering. Some safes had to be re-covered twice, and most of them were quite useless for keeping out flies. Wire gauze should be an authorised issue.

(*c*) *Grease Traps.*—Of the two types shown in Plate 4, the smaller one is the better. The large one is difficult to clean out and the tray should be larger. The small type is suitable for officers' and sergeants' messes and small units. Two small traps per battalion are better than one of the large pattern.

Entrances to the Camp.

9. (*a*) The main entrance to the camp from the London Road was improved by laying old road metal 4-in. thick and steam rolling it. This metal was delivered to the site at 7s. a ton by the Basingstoke Urban District Council. It was much cheaper than sleepers and the road was far more satisfactory. About 30 yards of road was laid down.

(*b*) A new entrance was made east of the above, but as there was no slope on the ground at the point chosen, very little metalling was required.

(*c*) For the R.A.S.C. Depot, a loop road 110 yards long and 12ft. wide was provided. This was made with road metal as described in (*a*) above. Without this road, lorries could not have entered the depot, and the working of the depot would have been very difficult. The road stood up well to the work. It was very quickly made and no foundation or excavating was attempted. (See Photo No. 1, South Corner of Camp, and Photo No. 7.)

The total cost of these three entrances was £29, 76 tons of metalling being used. Sleeper roads would have taken three times as long to lay and would have been double the cost.

Subsidiary Works.

10. (*a*) As the electric power and lighting mains of the Basingstoke town supply ran alongside the camp, it was decided to instal a small circular saw. This was an 18-in. saw driven by a 20 h.p. D.C. motor. It was extremely useful, especially when an extra demand for duckboards arose on account of very bad weather. The cost of installation of power lines and meter was £7.

(*b*) Electric light was laid on to the 11th Field Co. lines, Brigade Headquarters, R.A.M.C., and the Officers' Messes of the four battalions. The cost of this was borne by the units concerned. Since the stores were returned when the camp was dismantled, and since extremely favourable terms were obtained from the Basingstoke Borough Electrical Engineer, the cost per unit was very small, and the lighting was much cheaper than lamps or candles.

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Installation charges and current consumed came to £2 6s. 8d. per battalion officers' mess.

(*c*) Two thousand feet of four-strand wire fence was erected to rail off a " right of way " from the camp on the western boundary.

(*d*) A considerable number of notice boards were required, and also posts for marking roads throughout the camp. It is important not to forget these articles when making out lists of stores.

Water Supply.

(*a*) *Consumption.*

11. The estimated consumption of water was 30,000 gallons per diem. The Waterworks Engineer of Basingstoke agreed to supply this by tapping a 3-in. main near the camp, on condition that sufficient storage was installed to deal with the peak load. A 2-in. meter was asked for, but was refused on the grounds that the supply to the civil population would be cut short. A 1-in. meter was, therefore, installed. The pressure was 70-75 lbs. per sq. inch. The curves in Plate 2 show :—

Curve (1).—The supply from the 1-in. meter under test. The Waterworks Engineer was asked to make this test to give data on which to calculate the storage required.

Curve (2) was then made out, showing the estimated consumption. A study of these two curves showed that storage of about 9,000 gallons was required to deal with the evening load—chiefly washing. Consumption between 3 p.m. and 8 p.m. was estimated at 18,000 gallons and supply would be 9,000 gallons.

Curve (3) shows the actual average consumption. This curve was made out after experience of the working of the system had been gained. It will be noted that the morning load was more prolonged than anticipated, and that the evening load was smaller than estimated. The latter was due to the extraordinary cold weather during camp. Had the weather been very hot, there would have been a very great strain put upon the system. The actual average consumption was 20,000 gallons per day.

Water Points.

(*b*) A water point was authorised for each unit, and after an investigation of Curves (1) and (2) the storage decided upon was :—

One 2,400 gallon Water Point.
Four 1,600 ,, ,, Points.
Two 400 ,, ,, ,,

Total storage 9,600 gallons. Two-in. mains with 1-in. service pipes were used.

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The general arrangements for water supply were :—

(1) One 100 or 150 gallon tank to be provided at each cookhouse to be filled by unit watercarts from the waterpoint. (See Photo No. 3.)

(2) Ablution benches to be near the water point so that basins could be filled from the taps and taken to the benches.

(3) Horse troughs (600 gallon) were supplied direct from the mains with a low stand pipe.

Each water point, therefore, had to have—

(i) A 1-in. down pipe with stop cock and 1½-in. hose on the end, for water-cart filling.

(ii) A row of taps for ablution and water bottle filling.

For bathing purposes shower baths on a scale of five per battalion were erected (see Photo No. 5). These were put direct on the main in order to provide sufficient pressure.

The general design of the water points is shown in photo No. 6. The following points in design call for notice :—

(i) It is absolutely necessary to put the tanks ten-feet high to give reasonable pressure for filling basins and water bottles.

(ii) A stop cock must be fitted on each down pipe.

(iii) A bench is required on which to rest buckets and basins to prevent men hanging them on the taps.

Time for Erection.

(*c*) The water supply system was erected in 17 working days by 13 pioneer plumbers and two Class II. plumbers with a sergeant in charge. A labour party of two N.C.O.'s and 10 men did the unskilled work.

The piping was secondhand, which necessitated plugging and testing the portion laid twice daily, and also the tanks were not new and had to be patched. The pioneer plumbers were from the Army Vocational Training Centre and had had no previous experience of this work. With skilled plumbers and good material the work could have been done in 12 or 14 working days.

Maintenance Party.

(*d*) A maintenance party of two plumbers ran this water supply during camp. Their chief work was the repair of taps and keeping the water points full. The daily duties of these men on the latter work is indicated in Plate No. 2.

The reason why this party had to fill the water points regularly was that the supply from the town mains could not be brought into the camp at the highest point of the system, and there was not enough pressure to fill all points simultaneously. Great care had, therefore, to be exercised in manipulating stop cocks so that all parts of the system were kept fully supplied.

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Points Regarding Water Supply.

(*e*) The following points should be noted as regards water supply of camps in future :—

(1) It is best to run a short length of pipe from the water points to the ablution benches and to have the taps on the benches.

(2) A stop cock must be provided on each branch of the system to enable refilling to be carried out.

(3) To prevent waste of water very strict orders must be issued to units. It is suggested that the Engineer Officer in charge should draft out these orders and that they should be issued by Brigade to all units in camp.

(4) A timed programme for the use of shower baths is necessary if the best use is to be made of them.

Water Supply Stores.

(*f*) Appendix 6 shows the water supply stores actually ordered for this system, and will give an indication of what is required for work of this nature. An important item as regards water supply work is the equipment of tools. A Field Company does not possess many of these articles, and they must be obtained from store. Appendix 6 shows what was taken out to Basingstoke.

APPENDIX. 1.

SCALE of CAMP ACCESSORIES laid down by Command H.Q. issued under 2nd Division Administrative Instructions for Manœuvres, 1925, No. 1.

1. WATERING.	600 gallon troughs	1 per 100 horses.	
2. COOKHOUSES.	Infantry Battalion	Officers	1 small.
		Sergts.	1 small.
		O. Ranks	1 large.
	Other units in proportion.		
3. GREASE TRAPS.	One per Cookhouse.		
4. MEAT SAFES.	,, ,, ,,		
5. INCINERATORS.	One per battalion, or equivalent.		
6. ABLUTION.	Double benches 11′ lengths, duckboards on each side, 40 ft. run for 1,000 men.		
	Average 2 lengths per battalion waterpoint.		
7. BATHING.	One 2,300-gallon tank per 1,000 men.		
8. LATRINES.	(*a*) One single seat box. 1 per 6 officers.		
	(*b*) Ten-seat boxes. 10 seats per 100 men.		
	C.I. shelter to be put over.		
	C.I. sides. Canvas backing.		
	Latrine screens to be put up by each unit.		
9. URINALS.	Single. 6 ft. C.I. bent J shape on uprights.		
	Double. One on each side of uprights.		
	Scale :— Group of Officers' Latrines		1 single.
	Each N.C.O.'s ,,		1 single.
	Each pair of 10-seater latrines		1 double.

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REQUIREMENTS OF UNITS. APPENDIX 2.

Unit.	Cookhouses		Grease Traps.	Meat Safes.	Incinera-tors.	Water Tanks, (i) Stands for (ii) Covers for	Latrines.		Urinals.	Ablution Benches. (11ft. Lgths).	Horse Troughs. (complete)
	Large	Small					Officers	O. Ranks (10 seats)			
H.Q. 4th Gds. Bde. Bde. H.Q. Sig. Sec.	—	1	1	1	—	1	5	—	2	—	—
2nd Bn. Gren. Gds.	1	2	3	3	1	3	8	5	6	4	1
3rd Bn. Cold. Gds.	1	2	3	3	1	3	8	6	6	4	1
1st Bn. Irish Gds.	1	2	3	3	1	3	8	6	6	4	1
1st Bn. Welsh Gds.	1	2	3	3	1	3	8	6	6	4	1
19th Fd. Bde. R.A. R.A. Bde. Sig. Sec.	—	5	5	5	2	5	4	3	4	2	4
19th Pack Bty., R.A.	—	3	3	3	1	3	2	2	3	2	2
1st Sqdn. Life Gds.	—	2	3	2	1	1	2	1	3	1	1
11th Fd. Co., R.E.	—	3	3	3	1	2	2	1	3	1	1
"O" Batty., R.H.A.	—	3	3	3	1	3	2	1	3	1	2
R.A.S.C. (Depot)	—	1	1	1	1	1	—	—	—	1	—
R.A.M.C. (Hospital)	—	—	1	—	—	—	3	—	1	—	—
N.A.A.F.I.'s (3)	—	—	3	—	—	—	—	—	—	—	—
Totals	4	26	35	30	11	28	52	31	43	24	14

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Camp Accessory.	Number required from Appendix 2	Timber Foot run. 5" x 3", 4" x 3", 3" x 2", 9" x 1", 6" x 1", 3" x 1"	Corrugated Iron Sheets. 6' 9'	Nails lbs. 4", 3", 2½", 2", 1"	Angle Irons	Plain Wire No. 12 S.W.G Coils 28 lbs.	Leather 1" wide. ft. run.	Biscuit Tins.	Muslin. Yards	Barbed Wire. Coils 28 lbs.	Staples.	Horse Troughs 600 gall. complete.	Remarks
Cook shelters, large ..													
,, ,, small ..													
Grease traps, large ..													
,, ,, small ..													
Meat Safes													
Incinerators													
Water Tank Stands ..													
,, ,, Covers ..													
Latrine Shelters													
Two Seats													
Four Seats													
Ten Seats													
Twenty Seats ..													
Sixty Seats													
Latrine Seats													
Single													
Ten Seats													
Urinals													
Ablution Benches ..													
Duckboards													
Horse Troughs													
Trestles for Storage Tanks													
Posts & Notice Boards ..													
Subsidiary Works ..													
Total													
Add 10% contingencies ..													
Total to be ordered ..													

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APPENDIX 4.

BASINGSTOKE COMMON CAMP LAY OUT. AREAS ALLOTTED TO UNITS.

	Feet.
Brigade Headquarters	700 x 150
Infantry Battalions (each) ...	700 x 400
Squadron Life Guards	540 x 300
"O" Battery, R.H.A.	600 x 300
Field Artillery Brigade—	
Officers' Lines	160 x 160
Battery Lines (each)... ...	280 x 160
Battery Horse Lines (each) ...	420 x 80
Gun Park (Brigade)	640 x 140
Pack Battery, R.A.	420 x 140
11th Field Company, R.E. ...	430 x 320
R.A.S.C. Depot.	350 x 250

APPENDIX 5.

LISTS OF MATERIALS REQUIRED FOR CAMP ACCESSORIES.

WATER POINT OF 6-400 GALLON TANKS.

TIMBER.

Rough Hewn Logs 12"-15" cut to size ...	9
5" x 4"	200 F.R.
4" x 1"	60 F.R.
3" x 2"	250 F.R.

NAILS.

6"	4 lbs.
4"	1 lb.
3"	2½ lbs.

DOGS. 18

N.B.—Water supply stores and piping omitted.

LARGE COOK SHELTER.

CORRUGATED GALVANISED IRON 6' SHEETS.

	Roof 20 sheets.		Total 40 Sheets.
	Back 10 sheets.		
	Ends 10 sheets.		
WIRE	12 S.W.G.	80 F.R.	
TIMBER	3" x 2"	240 F.R.	
NAILS	3"	3 lbs.	
	4"	2½ lbs.	

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CONSTRUCTION OF BASINGSTOKE MANŒUVRE CAMP.

No. 1. Air View of Camp in occupation.

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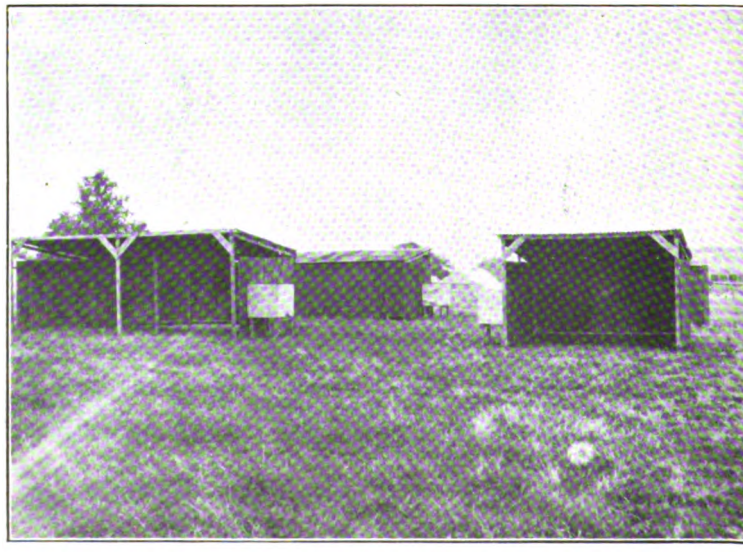
No. 2. R.E. Dump and Manufacturing Yard.



No. 3. Large and Small Cook Shelters.

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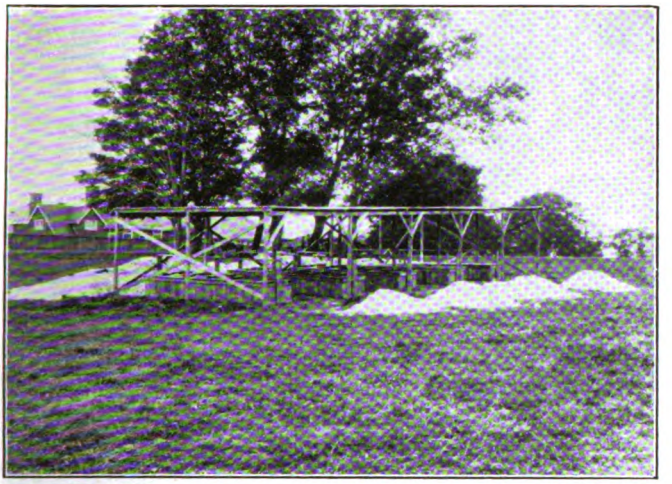
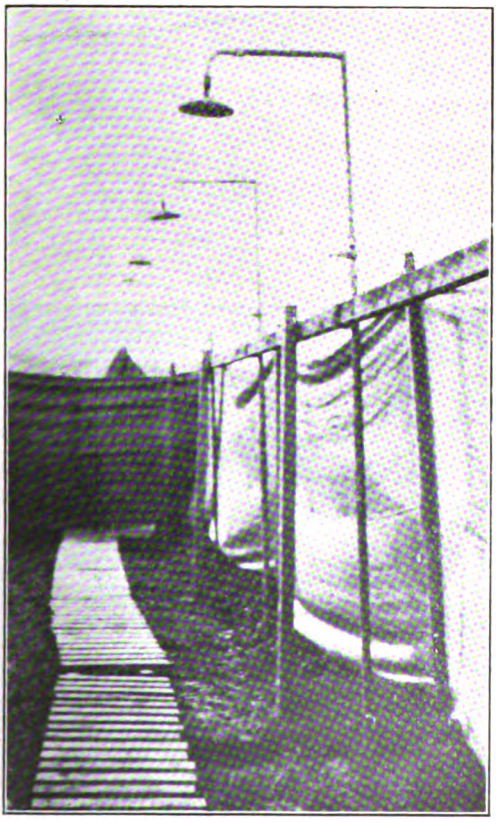


No. 4. Latrines for One Battalion—Screens not yet erected.



No. 5. Showers for One Battalion.

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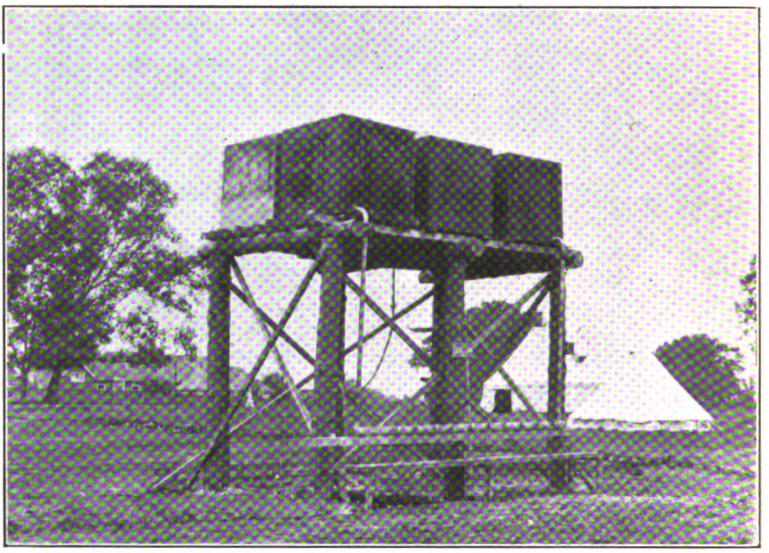

No. 6. Details of Water Point for Bde. Hd. Qrs. and One Battalion.

No. 7. Making entrance to R.A.S.C. Depot.

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— PLAN OF BASIN (

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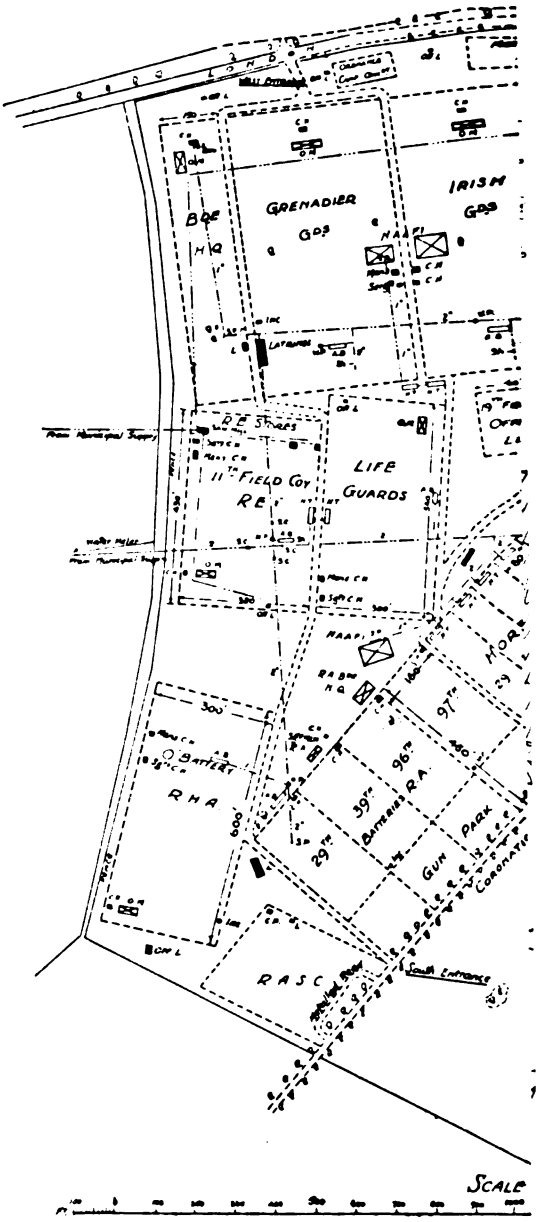

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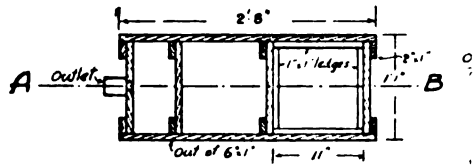
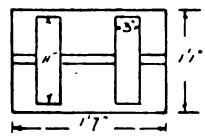
— GREASE TRA



PLAN.



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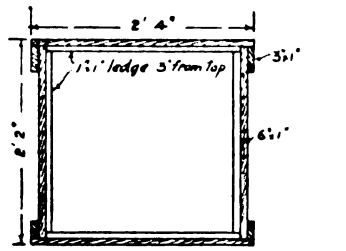
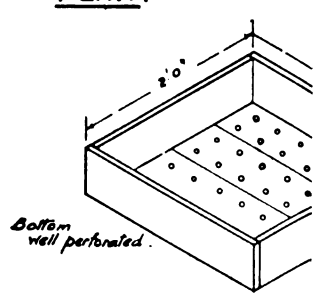
DETAILS OF SI



PLAN.



TRAY.

LARGE GRE

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SMALL COOK SHELTER.

CORRUGATED GALVANISED IRON 6′ SHEETS.

	Roof 12 sheets.		Total	
	Back 6 sheets.		28	
	Ends 10 sheets.		Sheets.	
WIRE	12 S.W.G.	80 F.R.		
TIMBER	3″ x 2″	190 F.R.	6″ x 1″	8 F.R.
NAILS	3″	2½ lbs.		
	4″	2 lbs.		

LATRINE SHELTER (THREE BAYS).

GALVANISED CORRUGATED IRON 9′ SHEETS				21 Sheets.
TIMBER	3″ x 2″	300 F.R.	3″ x 1″	100 F.R.
NAILS	3″	3 lbs.	4″	2 lbs.

ABLUTION BENCH.

TIMBER	9″ x 1″	25 F.R.
	3″ x 2″	20 F.R.
	3″ x 1″	25 F.R.

GALVANISED CORRUGATED IRON 1-6′ SHEET cut to shape.

NAILS	3″	1 lb.	4″	¼ lb.

NOTE—Bench should be 11′ 0″ long c.f. M.F.W. Plate 131.

INCINERATOR.

ANGLE IRON PICKETS	9
6′ SHEETS C.I.	6
WIRE 12 S.W.G.	6 yds or ½ lb.

MEAT SAFE.

TIMBER	6″ x 1″	100 F.R.	3″ x 2″	50 F.R.		
	3″ x 1″	40 F.R.	1″ x 1″	15 F.R.		
	1″ x ¼″	50 F.R.				
NAILS	6″	½ lb.	4″	1 lb.	2½″	2½ lbs.
	2″	¼ lb.	½″	¼ lb.		

MUSLIN 30 yds.

HOOKS, STEEL MEAT 2 or 3.

LEATHER HINGES 3.

NOTE.—The meat safe can be improved by the addition of two shelves, in which case 180 F.R. of 6″ x 1″ is required.

BASINGSTOKE CAMP—APPENDIX 6.

WATER SUPPLY STORES.

Piping Tubes 4″ (12 feet long)	5
Piping 2″	5,000 ft. run
,, 1″	2,500 ,, ,,
Piping pieces 2″	20
,, ,, 1″	20
Gunmetal Fullway valves 2″	10
,, ,, ,, 1″	10

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Stopcocks 2"	1
Connectors Screw long 2"	10
,, ,, short 2"	10
Tees 4" to 2"	10
,, 2" equal	20
,, 2" to 1"	14
Crosses 2"	1
Bends 2"	32
,, 1"	40
Sockets 2"	20
,, 1"	20
Sockets Reducing 2" to 1"	16
Backnuts 2"	62
,, 1"	46
Ball-valves 1"	10 (3 spare)
Bib-cocks 1"	85
,, ½"	32
Plugs 4"	10
,, 2"	12
,, 1"	1
Rubber Sheeting for Washers	7 lbs.
Showers complete with Bib-cock	24
Tallow and Tow	14 lbs. of each
Tanks 400 galls.	25
Tanks 100 and 150 galls. (for Cookhouses)	28
Delivery Hose 1½" (for Water points)	7 lengths
Dogs 12"	100
Trees (14 ft. long) (9"-12" diameter)	60
Timber (5" x 4")	1,000 F.R.
(3" x 2")	2,000 F.R.

Also lead, bolts, nuts and washers for repair of Tanks.

EXTRA TOOLS FOR WATER SUPPLY.

Screw cutting machine (hand) (Field Company Equipment) ...	...
Pipe Wrenches, flat link 4"	...
,, ,, ,, 2"	...
,, ,, ,, 1"	...
Stocks and Dies (Gas) 2"	...
,, ,, ,, 1"	...
Spanners, Stillson	...
Cold Chisels	...
Files, round	...
Tools, pipe cutting, three wheel 2"	...
,, ,, ,, ,, 1"	...
Ratchet drilling and tapping machine	...
Plumber's bench (to be constructed)	...
Vices pipe (Field Company Equipment)	...

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BATTLE HONOURS OF ROYAL ENGINEERS UNITS, (Continued).

N.B. "Somme 1916" counts as an extra honour for participation in any of the battles from Albert, 1916 to Ancre, 1916 inclusive.

MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
4TH ARMY.			
No. 1 Special Batn.	Special Brigade G.H.Q.	N.E.	
No. 2 Special Batn.	,,	D.	"G" Co. working under C.E. III Corps in area.
110th Railway Co.	G.H.Q.	D.	Working on Meulte-Martinpuich Railway.
119th Railway Co.	,,	N.E.	
178th Tunnelling Co.	,,	E	
179th Tunnelling Co.	,,	,,	
183rd Tunnelling Co.	,,	,,	
4th Pontoon Park	4th Army	,,	
5th Pontoon Park	,,	N.E.	
No. 4 Bridging Unit (IWT)	,,	D.	No diary.
4th Field Survey Co.	,,	,,	No diary.
III CORPS.			
214th Army Troops Co.	III Corps	N.E.	
221st Army Troops Co.	,,	E	
281st Army Troops Co.	,,	,,	
282nd Army Troops Co.	,,	N.E.	
1/3rd Cornwall A.T. Co.	,,	D.	No diary.
No. 2 Labour Batn. R.E.	,,	,,	"C" Co. repairing roads in area.
XIV CORPS.			
142nd Army Troops Co.	XIV Corps	E.	
216th Army Troops Co.	,,	D.	No diary.
232nd Army Troops Co.	,,	,,	No diary
238th Army Troops Co.	,,	N.E.	
280th Army Troops Co.	,,	E.	
1/1st Wilts A.T. Co.	,,	,,	
No. 1 Labour Batn. R.E.	,,	,,	
XV CORPS.			
133rd Army Troops Co.	XV Corps	E.	
134th Army Troops Co.	,,	,,	
149th Army Troops Co.	,,	N.E.	
217th Army Troops Co.	,,	E.	
2nd Indian Field Sqdn.	2nd Indian Cav. Div.	,,	Attached XV Corps.
III CORPS.			
23rd Field Co.	1st Div.	,,	
26th Field Co.	,,	,,	
1/1st Lowlands Fd. Co.	,,	,,	
101st Field Co.	23rd Div.	,,	
102nd Field Co.	,,	,,	
128th Field Co.	,,	,,	

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MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
III CORPS.			
1/1st Northumbrian Field Co.	50th Div.	E.	
1/2nd Northumbrian Field Co.	,,	,,	
7th Field Co.	,,	,,	
74th Field Co.	15th Div.	,,	Working on roads and huts in area.
XIV CORPS.			
55th Field Co.	Guards Div.	,,	
75th Field Co.	,,	,,	
76th Field Co.	,,	,,	
59th Field Co.	5th Div.	,,	
1/2nd Durham Fd. Co.	,,	,,	
1/2nd Home Counties Fd. Co.	,,	,,	
12th Field Co.	6th Div.	,,	
1/1st London Fd. Co.	,,	,,	
2/2nd West Riding Fd. Co.	,,	,,	
83rd Field Co.	20th Div.	,,	
84th Field Co.	,,	,,	
96th Field Co.	,,	,,	
1/1st Edinburgh Fd. Co.	56th Div.	,,	
2/1st London Fd. Co.	,,	,,	
2/2nd London Fd. Co.	,,	,,	
XV CORPS.			
97th Field Co.	21st Div.	,,	
98th Field Co.	,,	,,	
126th Field Co.	,,	,,	
1/1st West Lancs. Fd. Co.	55th Div.	,,	
2/1st West Lancs. Fd. Co.	,,	,,	
2/2nd West Lancs. Fd. Co.	,,	,,	
1st New Zealand Fd. Co.	New Zealand Div.	,,	
2nd New Zealand Fd. Co.	,,	,,	
3rd New Zealand Fd. Co.	,,	,,	
228th Field Co.	41st Div.	,,	Attached 21st Divn.
233rd Field Co.	,,	,,	Repairing roads in area.
237th Field Co.	,,	,,	

SIGNAL COMPANIES.

MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
4TH ARMY.			
4th Army Signal Co.	4th Army	N.E.	
III CORPS.			
III Corps Signal Co.	III Corps	E.	
XIV CORPS.			
XIV Corps Signal Co.	XIV Corps	,,	
XV CORPS.			
XV Corps Signal Co.	XV Corps	,,	
III CORPS			
1st Div. Signal Co.	1st Div.	,,	
23rd Div. Signal Co.	23rd Div.	,,	
50th Div. Signal Co.	50th Div.	,,	

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MORVAL. 25TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
XIV CORPS			
Guards Div. Signal Co.	Guards Div.	E.	
5th Div. Signal Co.	5th Div.	,,	
6th Div. Signal Co.	6th Div.	,,	
20th Div. Signal Co.	20th Div.	,,	
56th Div. Signal Co.	56th Div.	,,	
XV CORPS.			
21st Div. Signal Co.	21st Div.	,,	
55th Div. Signal Co.	55th Div.	,,	
N.Z. Div. Signal Co.	New Zealand Div.	,,	

THIEPVAL. 26TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
RESERVE (5TH) ARMY.			
119th Railway Co. R.E.	G.H.Q.	E.	
174th Tunnelling Co. R.E.	,,	,,	
179th Tunnelling Co. R.E.	,,	,,	
252nd Tunnelling Co. R.E.	,,	N.E.	
230th Army Troops Co. R.E.	Reserve Army	D.	No diary.
1/1st Hants. A.T. Co.	,,	N.E.	
No 2 Siege Co. R. Anglesey.	,,	,,	
No 6 Labour Bn. R.E.	,,	D.	
5th Field Survey Co. R.E.	,,	,,	No diary.
No. 12 Pontoon Park	,,	N.E.	
No. 5 Pontoon Park	,,	E.	Nos. 2, 3, 4 Sections only
II CORPS.			
135th Army Troops Co. R.E.	II Corps	N.E.	
148th Army Troops Co. R.E.	,,	E.	
67th Field Co. R.E.	11th Div.	,,	
68th Field Co. R.E.	,,	,,	
86th Field Co. R.E.	,,	,,	
79th Field Co. R.E.	18th Div.	,,	
80th Field Co. R.E.	,,	,,	
92nd Field Co. R.E.	,,	N.E.	
V CORPS			
4th Siege Co. R. Monmouth R.E.	V Corps	N.E.	
225th Field Co. R.E.	39th Div.	D.	
227th Field Co. R.E.	,,	,,	
234th Field Co. R.E.	,,	N.E.	
CANADIAN CORPS.			
1st Can. A.T. Co. R.E.	Canadian Corps	N.E.	
No. 1 Siege Co. R. Monmouth R.E.	,,	,,	
1st Can. Field Co. R.E.	1st Can. Div.	,,	
2nd Can. Field Co. R.E.	,,	,,	
3rd Can. Field Co. R.E.	,,	,,	
4th Can. Field Co. R.E.	2nd Can. Div.	E.	
5th Can. Field Co. R.E.	,,	,,	
6th Can. Field Co. R.E.	,,	,,	
7th Can. Field Co. R.E.	3rd Can. Div.	,,	
8th Can. Field Co. R.E.	,,	N.E.	
9th Can. Field Co. R.E.	,,	,,	

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SIGNALS—RESERVE ARMY.

THIEPVAL. 26TH-28TH SEPTEMBER, 1916.

Unit.	Formation.		Remarks.
Reserve Army Signal Co.	Reserve Army	N.E.	
II Corps Signal Co.	II Corps	N.E.	
11th Divl. Signal Co.	11th Div.	E.	
18th Divl. Signal Co.	18th Div.	,,	
" O " Corps Signal Co.	V Corps	N.E.	
39th Divl. Signal Co.	39th Div.	E.	
Canadian Corps Signal Co.	Canadian Corps	N.E.	
1st Can. Divl. Signal Co.	1st Can. Div.	E.	
2nd Can. Divl. Signal Co.	2nd Can. Div.	,,	
3rdCan. Divl. Signal Co.	3rd Can. Div.	D.	Relieved 1st Can. Divl. Signal Co. on 28th September, 1916

NOTE.—The smaller Signal Units, E.9 Airline and Cable Sections are not included as it is quite impossible to trace them.

LE TRANSLOY. 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
4TH ARMY.			
No. 3 Special Co.	Special Brigade G.H.Q.	E.	
No 4 Special Co.	,,	,,	
No. 1 Special Battn.	,,	N.E.	
No. 2 Special Battn.	,,	D.	" F " Co. in oil mortar attack 7th October, 1916.
110th Railway Co.	G.H.Q.	N.E.	
119th Railway Co.	,,	,,	
178th Tunnelling Co.	,,	D.	
179th Tunnelling Co.	,,	,,	
183rd Tunnelling Co.	,,	E.	
133rd Army Troops Co.	XV Corps	N.E.	
142nd Army Troops Co.	XIV Corps	,,	
149th Army Troops Co.	XV Corps	,,	
214th Army Troops Co.	III Corps		
216th Army Troops Co.		D.	No diary.
217th Army Troops Co.		N.E.	
221st Army Troops Co.	III Corps	,,	
232nd Army Troops Co.	XIV Corps	D.	No diary.
238th Army Troops Co.	III Corps	N.E.	
280th Army Troops Co.	XIV Corps	,,	
281st Army Troops Co.	III Corps	,,	
282nd Army Troops Co.	III Corps	,,	
1/3rd Cornwall A.T. Co.	III Corps	D.	No diary.
1/1st Sussex A.T. Co.	XV Corps	,,	No diary
1/1st Wilts A.T. Co.		N.E.	
4th Field Survey Co.	4th Army	D.	No diary.
No. 4 Pontoon Park	,,	N.E.	
No. 5 Pontoon Park	,,	,,	
No. 4 Bridging Unit (I.W.T.)	,,	D.	No diary.
No. 1 Labour Battn. R.E.	XIV Corps	N.E.	
No. 2 Labour Battn. R.E.	XV Corps	,,	
III CORPS			
63rd Field Co.	9th Div.	E.	
64th Field Co.	,,	,,	
90th Field Co.	,,	,,	
73rd Field Co.	15th Div.	,,	
74th Field Co.	,,	N.E.	
91st Field Co.	,,	D.	Working on Tramway at Martinpuich.

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LE TRANSLOY. 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
III CORPS.			
101st Field Co.	23rd Div.	N.E.	
102nd Field Co.	,,	E.	
128th Field Co.	,,	N.E.	
1/3rd London Field Co.	47th (London) Div.	E.	
1/4th London Field Co.	,,	,,	
2/3rd London Field Co.	,,	,,	
7th Field Co.	50th (Northumbrian) Div.	,,	
1/1st Northumbrian Fd. Co.	,,	,,	
1/2nd Northumbrian Fd. Co.	,,	N.E.	
XIV CORPS			
9th Field Co.	4th Div.	E.	
1/1st Durham Fd. Co.	,,	,,	
1/1st Renfrew Fd. Co.	,,	D.	
12th Field Co.	6th Div.	E.	
1/1st London Fd. Co.	,,	,,	
2/2nd West Riding Fd. Co.	,,	,,	
83rd Field Co.	20th Div.	,,	
84th Field Co.	,,	,,	
96th FieldCo.	,,	,,	
1/1st Edinburgh Fd. Co.	56th Div.	,,	
2/1st London Fd. Co.	,,	,,	
2/2nd London Fd. Co.	,,	D.	
XV CORPS.			
69th Field Co.	12th Div.	E.	
70th Field Co.	,,	,,	
87th Field Co.	,,	,,	
1/2nd London Fd. Co.	29th Div.	,,	Attached to 12th Div
97th Field Co.	21st Div.	D.	
98th Field Co.	,,	,,	
126th Field Co.	,,	E.	
200th Field Co.	30th Div.	,,	
201st Field Co.	,,	,,	
202nd Field Co.	,,	,,	
228th Field Co.	41st Div.	,,	
233rd Field Co.	,,	,,	
237th Field Co.	,,	,,	
1st N.Z. Field Co.	New Zealand Div.	,,	
2nd N.Z. Field Co.	,,	,,	
3rd N.Z. Field Co.	,,	N.E.	
RESERVE (5TH) ARMY.			
174th Tunnelling Co.	G.H.Q.	N.E.	
252nd Tunnelling Co.	,,	,,	
134th Army Troops Co.	II Corps	D.	No diary.
236th Army Troops Co.	Reserve Army	,,	No diary.
1/1st Hants Army Troops	V Corps	N.E.	
5th Field Survey Co.	Reserve Army	D.	No diary.
No. 12 Pontoon Park	,,	N.E.	
No. 6 Labour Bn. R.E.	,,	,,	
CANADIAN CORPS.			
1st Canadian Army Troops Co.	Canadian Corps	N.E.	
2nd Canadian Army Troops Co.	,,	,,	
3rd Canadian Army Troops Co.	,,	,,	
1st Canadian Field Co.	1st Can. Div.	,,	
2nd Canadian Field Co.	,,	,,	
3rd Canadian Field Co.	,,	,,	

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LE TRANSLOY, 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
CANADIAN CORPS,			
4th Canadian Field Co.	2nd Can. Div.	N.E.	
5th Canadian Field Co.	,,	,,	
6th Canadian Field Co.	,,	,,	
7th Canadian Field Co.	3rd Can. Div.	,,	
8th Canadian Field Co.	,,	,,	
9th Canadian Field Co.	,,	,,	
10th Canadian Field Co.	4th Can. Div.	D.	
11th Canadian Field Co.	,,	N.E.	
12th Canadian Field Co.	,,	D.	

SIGNALS.

LE TRANSLOY. 1ST-18TH OCTOBER, 1916.

Unit.	Formation.		Remarks.
4th Army Signal Co.	4th Army	N.E.	
No. 4 Army Wireless Co.	,,	D.	No diary.
C Corps Signal Co.	III Corps	N.E.	
9th Div. Signal Co.	,,	E.	
15th Div. Signal Co.	,,	,,	
23rd Div. Signal Co.	,,	,,	
47th Div. Signal Co.	,,	,,	
50th Div. Signal Co.	,,	,,	
J Corps Signal Co.	XIV Corps	N.E.	
4th Divl. Signal Co.	,,	E.	
6th Divl. Signal Co.	,,	,,	
20th Divl. Signal Co.	,,	,,	
56th Divl. Signal Co.	,,	,,	
P Corps Signal Co.	XV Corps	N.E.	
12th Divl. Signal Co.	,,	E.	
21st Divl. Signal Co.	,,	D.	
30th Divl. Signal Co.	,,	E.	
41st Divl. Signal Co.	,,	,,	
N.Z. Divl. Signal Co.	,,	,,	
Reserve Army Signal Co.	Reserve Army	N.E.	
No. 5 Army Wireless Co.	,,	D.	No diary.
Canadian Corps Signal Co.	Canadian Corps	N.E.	
1st Can. Divl. Signal Co.	,,	,,	
2nd Can. Divl. Signal Co.	,,	,,	
3rd Can. Divl Signal Co.	,,	,,	
4th Can. Divl. Signal Co.	,,	,,	

ANCRE HEIGHTS. 1ST OCTOBER-11TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
RESERVE ARMY (5TH).			
No. 2 Special Co.	Special Brigade G.H.Q.	E.	
No. 1 Special Battn.	,,	D.	
119th Railway Co.	G.H.Q.	N.E.	
110th Railway Co.	,,	,,	
174th Tunnelling Co.	,,	E.	
179th Tunnelling Co.	,,	,,	
252nd Tunnelling Co.	,,	N.E.	
236th Army Troops Co.	5th Army	D.	No diary.
1/1st Hants A.T. Co.	,,	N.E.	
No. 1 Siege Co. R. Monmouth	V Corps	,,	
No. 4 Siege Co. R. Monmouth.	X Corps	,,	
No. 2 Siege Co. R. Anglesey	XIII Corps	,,	

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ANCRE HEIGHTS. 1ST OCTOBER-11TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
RESERVE ARMY (5th).			
5th Field Survey Co.	5th Army	D.	No diary.
No. 5 Pontoon Park	,,	,,	
No. 12 Pontoon Park	,,	N.E.	
No. 6 Labour Bn. R.E.	XIII Corps	,,	
II CORPS.			
134th Army Troops Co.	II Corps	D.	No diary.
135th Army Troops Co.	,,	E.	
148th Army Troops Co.	,,	,,	
1st Field Sqn.	1st Can. Div.	,,	Attached 18th Div.
67th Field Co.	11th Div.	,,	Attached 18th Div.
68th Field Co.	,,	,,	Attached 18th Div.
86th Field Co.	,,	D.	Attached 18th Div.
79th Field Co.	18th Div.	E.	
80th Field Co.	,,	,,	
92nd Field Co.	,,	,,	
219th Field Co.	32nd Div.	,,	Attached 18th Div.
81st Field Co.	19th Div.	E.	
82nd Field Co.	,,	,,	
94th Field Co.	,,	D.	
105th Field Co.	25th Div.	E.	
106th Field Co.	,,	,,	
130th Field Co.	,,	,,	
206th Field Co.	32nd Div.	,,	
218th Field Co.	,,	,,	
219th Field Co.	,,	,,	
225th Field Co.	39th Div.	,,	
227th Field Co.	,,	,,	
234th Field Co.	,,	,,	
CANADIAN CORPS.			
1st Can. A.T. Co.	Can. Corps	N.E.	
2nd Can. A.T. Co.	,,	,,	
3rd Can. A.T. Co.	,,	E.	
1st Can. Field Co.	1st Can. Div.	N.E.	
2nd Can. Field Co.	,,	E.	
3rd Can. Field Co.	,,	,,	
4th Can. Field Co.	2nd Can. Div.	N.E.	
5th Can. Field Co.	,,	,,	
6th Can. Field Co.	,,	,,	
7th Can. Field Co.	3rd Can. Div.	E.	
8th Can. Field Co.	,,	,,	
9th Can. Field Co.	,,	,,	
10th Can. Field Co.	4th Can. Div.	,,	
11th Can. Field Co.	,,	,,	
12th Can. Field Co.	,,	,,	

SIGNALS.

ANCRE HEIGHTS. 1ST OCTOBER-11TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
Reserve Army Signal Co.	5th Army	N.E.	
No. 5 Army Wireless Co.	,,	D.	No diary.
B Corps Signal Co.	II Corps	N.E.	
18th Divl. Signal Co.	,,	E.	
19th Divl. Signal Co.	,,	,,	
25th Divl. Signal Co.	,,	,,	
39th Divl. Signal Co.	,,	,,	
O Corps Signal Co.	V Corps	N.E.	
Canadian A.C. Signal Co.	Canadian A.C.	N.E.	
1st Can. Divl. Signal Co.	,,	E.	
2nd Can. Divl. Signal Co.	,,	,,	
3rd Can. Divl. Signal Co.	,,	,,	
4th Can. Divl. Signal Co.	,,	,,	

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ANCRE. 1916. 13TH-18TH NOVEMBER, 1916.

Unit.	Formation.		Remarks.
81st Field Co.	19th Divn.	E.	
82nd Field Co.	,,	,,	
94th Field Co.	,,	D.	
225th Field Co.	39th Divn.	E.	
227th Field Co.	,,	,,	
234th Field Co.	,,	,,	
10th Canadian Fd. Co.	4th Can. Divn.	E.	
11th Canadian Fd. Co.	,,	,,	
12th Canadian Fd. Co.	,,	,,	
V CORPS			
5th Field Co.	2nd Divn.	,,	
226th Field Co.	,,	,,	
1/1st East Anglian Fd. Co.	,,	,,	
56th Field Co.	3rd Divn.	,,	
1/1st Cheshire Fd. Co.	,,	,,	
1/1st E. Riding Fd. Co.	,,	,,	
206th Field Co.	32nd Divn.	,,	
218th Field Co.	,,	,,	
219th Field Co.	,,	,,	
152nd Field Co.	37th Divn.	,,	
153rd Field Co.	,,	,,	
154th Field Co.	,,	,,	
1/1st Highland Fd. Co.	51st (High) Divn.	,,	
1/2nd Highland Fd. Co.	,,	,,	
2/2nd Highland Fd. Co.	,,	,,	
1st Field Co. 63rd (R.N.) Div.	63rd (R.N.) Divn.	,,	
2nd Field Co. 63rd (R.N.) Div.	,,	,,	
3rd Field Co. 63rd (R.N.) Div.	,,	,,	
XIII CORPS			
210th Field Co.	31st Divn.	N.E.	
211th Field Co.	,,	E.	
223rd Field Co.	,,	D.	
224th Field Co.	40th Divn.	N.E.	
229th Field Co.	,,	,,	
231st Field Co.	,,	,,	
FOURTH ARMY.			
No. 1 Special Co.	Spec. Brig. G.H.Q.	E.	
No. 2 Special Co.	,,	,,	
No. 1 Special Battn.	,,	N.E.	
174th Tunnelling Co.	G.H.Q.	E.	
179th Tunnelling Co.	,,	N.E.	
183rd Tunnelling Co.	,,	,,	
252nd Tunnelling Co.	,,	E.	
1/1st S. Midland Field Co.	48th Divn.	D.	
1/2nd S. Midland Field Co.	,,	N.E.	
2/1st S. Midland Field Co.	,,	,,	
FIFTH ARMY.			
134th Army Troops Co.	II Corps	D.	No diary.
135th Army Troops Co.	,,	,,	
148th Army Troops Co.	,,	E.	
1/1st Devon A.T. Co.	XIII Corps	N.E.	
145th A.T. Co.	,,	,,	
3rd Canadian A.T. Co.	Canadian Corps	,,	
No. 1 Siege Co. R. Monmouth.	V Corps	,,	

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ANCRE. 1916. 13TH-18TH NOVEMBER, 1916.

Unit.	Formation.	Remarks.
FIFTH ARMY.		
No. 4 Siege Co. R. Monmouth.	X Corps	N.E.
No. 2 Siege Co. R. Anglesey	XIII Corps	D.
No. 6 (Labour) Bn. R.E.	,,	,,
II CORPS.		
67th Field Co.	11th Divn.	E.
68th Field Co.	,,	,,
86th Field Co.	,,	D.
79th Field Co.	18th Divn.	,,
80th Field Co.	,,	E.
92nd Field Co.	,,	,,

SIGNALS.

ANCRE, 1916. 13TH-18TH NOVEMBER, 1918.

Unit.	Formation.	Remarks.
4TH ARMY.		
4th Army Signal Co.	4th Army	N.E.
No. 4 Army Wireless Co.	,,	D. No diary.
C Corps Signal Co.	III Corps	N.E.
48th Divl. Signal Co.	,,	D.
5TH ARMY.		
5th Army Signal Co.	5th Army	N.E.
No. 5 Army Wireless Co.	,,	D. No diary.
B Corps Signal Co.	II Corps	N.E.
18th Divl. Signal Co.	,,	E.
19th Divl. Signal Co.	,,	,,
30th Divl. Signal Co.	,,	,,
4th Canadian Divl. Signal Co.	,,	,,
O Corps Signal Co.	V Corps	N.E.
2nd Divl. Signal Co.	,,	E.
3rd Divl. Signal Co.	,,	,,
32nd Divl. Signal Co.	,,	,,
37th Divl. Signal Co.	,,	,,
51st (High.) Divl. Signal Co.	,,	,,
63rd (R.N.) Divl. Signal Co.	,,	,,
N. Corps Signal Co.	XIII Corps	N.E.
31st Divl. Signal Co.	,,	E.
40th Divl. Signal Co.	,,	N.E.

To be continued.

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ENGINEER SERVICES.

A LECTURE GIVEN TO THE ARMY CLASS, LONDON SCHOOL OF ECONOMICS, LENT TERM, 1925.

By COLONEL J. W. S. SEWELL, C.M.G.

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IN order to get the utmost from auxiliary arms and services, a commander must sufficiently appreciate those conditions which impose limitations upon their output. The object of this lecture is to explain so far as the time at disposal permits, what are the limitations imposed by *force majeure* upon the R.E.

Whilst engineering is by no means a mystic cult acquired by esoteric processes, it of course possesses a technique which can no more be acquired from books and lectures alone, without years of experience, than can the science of commanding a battalion or a company of infantry. I shall therefore make no attempt to explain technical methods of execution, but will aim at giving a picture of the general system of control with a view to your acquisition of a sympathetic understanding of the work of the sapper and of the aid which he requires of you to carry out work for you.

Let me first show you in some perhaps exaggerated sketches what to avoid. A staff officer who does not understand the sapper's work is apt to demand far more output than can be effected with the means at disposal in the time available. You must realise at once—and this is going to be made perfectly clear in future revises of *Field Service Regulations*—that the man who orders a work is primarily responsible for ensuring that the means of execution, that is, men, material, and especially transport, are available.

Now we will suppose a division newly-formed, with a staff that have not a deep insight into engineering possibilities; which in consequence wants more than can be obtained. Of course it is the C.R.E.'s duty to point out this fact, and to ask for a priority programme. If you shake him off, he must and will make his own selection—probably not what you consider the most urgent items: this is not a happy beginning. It is still worse if you give a priority selection and then change your mind 48 hours later—rendering nugatory 48 hours' work of the R.E. and you know not how much of the C.R.E.'s energy. It is again bad work if you give a priority programme without due thought as regards your ability to supply your part of the mutual effort: or act in such a manner that the

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C.R.E. will discover that you have demanded as an essential something which you do not really regard as an essential.

For example, you demand that I, as C.R.E., shall make half a million bricks. Clearly I must find a bed of suitable clay: I shall want fuel for baking the bricks, and labour.

I find that the only patch of clay is occupied by a brigade camp. "G" for tactical reasons is unwilling to move them. "Q" thinks he can get the brigade to close up a bit and give me one corner but objects to carting the fuel so far. I rake together a gang of local cut-throats, whom "Q" promptly requisitions to unload some supplies. If I infer the bricks are not only going to cause me much trouble, but are not regarded by "Q" as very essential, shall I be far wrong? Are we not likely at this stage to misunderstand each other?

Programme of Work.

The moral of this is that you should act just as you would do, say, in packing for a foreign tour. Make up a list of what you would like to have and classify it as

(i) Essentials.
(ii) Important.
(iii) Non-essentials.

Clearly you must have essentials at all costs: you may as well save yourself trouble and cut out the non-essentials at once. Then you sum up the aggregate of your means in men and materials, and *transport* for obtaining the important services: you get in your own mind some idea of the order of priority of the important items: you then order the essentials to be done, and in consultation with your experts (in a joint conference preferably) determine how far your "means" will permit the important items to be carried out in the time available. Thus you can form a "programme." Retention of a reserve of energy is normally desirable.

As commander or staff officer it is *your* responsibility to see that the means are available for the execution of any work you may order. This principle applies both in peace and war. A trained officer has usually a very sound knowledge of the exact amount of assistance he may demand from an auxiliary arm. He is apt to be somewhat vague as regards the limitations of a "Service."

Limited Potentiality.

In order to acquire this essential knowledge, you must study the economic factors which impose those limitations. (This you can well do, as I am trying to show you, without any extensive knowledge of the technique of the Service.) These economic factors differ in peace and war. In war, for example, a director has in effect an

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unlimited call on the public purse: but limitations are imposed, as doubtless you have been informed by others, by other considerations; normally, by the amount of transport available at some stage or other; but also by available labour and the manufacturing output of the U.K. I have not time to dilate on that subject. In peace as you well know, a director is limited by the funds put at his disposal by Parliament, I am now going to take the general system of control of Engineer Services in peace as my theme and to explain the economics of the system of control.

DEFINITION OF ENGINEER SERVICE.

First, however, we must define what "Engineer Services" means both in peace and war.

Now *F.S.R.*, Vol. 1-66, says:—

1. Engineering work in a theatre of operations may be generally classified into:—

i. Field engineering.
ii. Works services.

It must be realised, however, that the line of demarcation between these categories, in certain cases, will be difficult to define.

2. Field engineering is intimately connected with tactical operations in progress or in contemplation, and is executed by the troops, including R.E. units, placed under a commander's orders, supplemented by such organized or unorganized civilian labour as may be necessary and available.

Works services, which are carried out under the responsibility of the D. of W. and his representatives, relate to all engineering work of a general nature other than field engineering work.

Read also *F.S.R.*, Vol. 1-43 (xvi), which defines the duties or some of them, which fall under the head of "Works Services." Now please note sentence in 1-66, "the line of demarcation will be hard to define." It is indeed: in fact it is recognised that the Engineers of front line formations must perforce incept as field engineering work, to be performed in the most hasty manner, works which are of the nature of works services, but if executed under the ægis of the D.W., would be executed in a more semi-permanent manner. For example, roads, water supply, division and brigade headquarters, shelters for troops, and camp accessories. The demarcation line will possibly have to be, either in effect or even by regulations, defined by a geographical line.

We may consider that there will in effect be a line some miles in rear of the front line, forward of which liability to attack will render it necessary to abdicate direct administrative control by G.H.Q.

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However, that may be, I think you will understand the difference between the work done by the R.E. in war, as an auxiliary arm for the commander of a fighting formation, and the work done as an administrative service for the Q.M.G. It is the latter class of work which in peace falls under the head of " Engineer Services." But whereas in war, provision is the important factor, and the requirements of the universal provider (the Q.M.G.) must be met; in peace, finance is the controlling factor, and a productive branch of the Army Council (the M.G.O.) is established, to whose available funds Q.M.G. must reduce his demands. Hence the control by the M.G.O. in peace of the branch which " produces " accommodation.

Classification of Engineer Service.

Now this " accommodation " may be divided into two categories—

(A) Buildings and other construction (*e.g.*, ranges) generally.

(B) Production where requisite (*i.e.*, where no local supply is available) of such consumables as electric light and water.

Let us consider first (A). Again expenditure must be divided into two heads :—

(i) Capital expenditure, on new construction.

(ii) Expenditure to maintain existing construction in an efficient state of repair.

Capital Services.

The financial authorities from Parliament downwards, are naturally and properly most careful about capital expenditure, for it will be obvious to all of you that additional construction involves a permanent increase of annual army expenditure in order to maintain it in repair : in consequence the control over capital expenditure is most strict and indeed involves the sanction of Parliament itself to every item of any magnitude. Note the qualification implied in the last two words : you will of course say " If Parliament is going to attempt to scrutinize the necessity for a new bit of fence round an officer's quarter or a new lathe in a workshop, or a new telephone line on a range, the scrutiny must be valueless, inasmuch as the maze of detail will be far too great for any such body as the Army Council even, let alone the Treasury and above the Treasury, the Public Accounts Committee, to spare time to give it all effective consideration." Quite so ! in consequence a hard line is drawn : every new service which costs over £2,500 to complete must be referred by the Army Council to the Treasury (and eventually to Parliament) for sanction. These we call " Part I Services." But for services which cost under £2,500, a bulk allotment is made by

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Parliament: this is purposely kept low and it is obviously necessary to ensure that Part I Services are not smuggled through by cutting them up into several Part II Services. That is the principle of control: let us see how it is operated.

PART I SERVICES ORIGINATED IN COMMAND.

The demand for a new service may originate in some quite subordinate command, *e.g.*, from an area or even a sub-area commander, who may consider that a new recreation room or ground or a new road or some barrack accessory (*e.g.*, a guard room) is necessary. Theoretically, he demands this from the C.R.E., who refers it to command: in effect the demand is naturally conjointly made: the commander sees M.G.A.: C.R.E. reports to C.E. Let us suppose that "Command" favours the scheme and does not "turn it down" out of hand. A preliminary estimate is called for: the work is scrutinized from every point of view, including, of course, possible reduction of cost by variation of the original proposal.

Then a letter is written to the War Office stating the reasons which support the proposal, the estimated cost, and any re-action which may result on, for example, the total cost of light and water consumed by the command. The W.O. may now turn down the scheme altogether, for reasons which have not come within the purview of the command; for example, it may be the intention of the Q.M.G. (though not yet published as a decision) to effect some alterations in barrack policy, such as will involve the occupation of the barracks in question, by a different arm of the Service, which would render nugatory the proposed addition.

But normally W.O. will accept the proposal in principle, and will now ask for further information in the form of a more detailed estimate (not worth preparation until the proposal had been tentatively accepted in principle) and sketch designs and a more detailed report of indirect results.

This is a troublesome stage for everybody and unless conducted with forbearance and tact may well lead to friction. On the side of the command, its R.E. executive probably are already overworked: it is trying, under those circumstances, to be asked to get out estimates, designs and reports for a service for which, however sympathetic the W.O. may be, it is fully recognised that it is most improbable that funds will be forthcoming for a long period, having in view existing commitments. From the W.O. aspect it is essential to ensure that the scheme has been very fully considered, that all "luxuries" have been lopped off, and that every expense has been listed, and all secondary effects have been reviewed. Commands with overworked R.E. are somewhat apt to put up schemes without full consideration. It has to be considered whether all such accessory

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work as drainage schemes, roads of access, fences, land questions, supply of water and light have been brought into the estimate. It has also to be considered—and these are points too often forgotten in commands—whether water and light are really available (the head of water may be insufficient to rise to proposed site—the W.D. generating station for E.L. may be already fully loaded). Finally it may well be that this construction and the provision to it of the necessary light or power or heat may be the last straw which renders it economic to scrap some existing system of supply and to instal more modern and more economic plant. Let us however suppose that all this work has been carried out. The W.O. now says "very well; you may put this proposal on your Estimates book." This means that it may be registered in command as a tentatively approved scheme; from amongst the total number so registered, M.G.A. may select some half dozen to put forward in September of each year to W.O. as proposals for inclusion in the ensuing year's army estimates. Please bear in mind these pet schemes of commands thus awaiting funds, whilst I turn to what is meantime going on at the War Office.

Part I.—Originating at War Office.

It will be obvious to you that the principal proposals for expenditure will result from the barrack policy of the Q.M.G. He alone can say to his colleagues—

(i) We have to find accommodation to replace that lost by the transfer of the Curragh Barracks. I propose we construct barracks for a division at Catterick.

(ii) New units have been added to the army (*e.g.*, an A.D. brigade, and a Tank Corps). We must provide accommodation.

(iii) The progress of mechanicalisation demands more extensive repair workshops.

(iv) The standard of living has gone up and the married establishment has been increased. In the interests of morale and recruiting the A.G. is pressing for dining rooms for troops: C.I.G.S. demands more training and lecturing accommodation and more schools. I want more married quarters for officers and men.

It will I think be obvious to you that only a small portion of the available funds can be devoted to the execution of the command schemes to which I alluded before, unless these are in effect accessory to the main programme of the Council.

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PART I FUNDS. ALLOCATION.

Now let us consider what funds are available: in effect the Army Council are working to a fixed sum (or rather a reducing sum total) for the whole army. Again, they must distribute the sum over the maintenance costs of personnel, the cost of training the army, and the cost of arming, equipping and housing the army. To keep a clear head is obviously difficult, and in general the distribution between these contending claims is kept roughly in a proportion known by long experience to produce good results. In consequence the sum available for the capital expenditure is approximately the same every year: let us assume a figure of £1,250,000 and turn to *Army Estimates* 1924/25, in order to see how such a sum is distributed. You will note that expenditure shows a total estimate, the sum expended in previous years, the sum to be spent in 1924/25 and a balance for future years.

I think it will be clear to you that such a service as Catterick, and indeed the majority of Part I Services, cannot be executed in one year, even were cash available. Indeed at Catterick the labour which contractors can maintain in that one locality will not permit of the expenditure of more than about £250,000 per annum out of an estimated total cost of £1,250,000 for that camp. Having in view the arrears of barrack construction owing to the war years, the loss of the Curragh barracks, and the re-organisation of the army, you will realise the very complex problem which the Q.M.G. has to face, and will hardly be surprised that the aggregate commitments (*i.e.*, the balance still to be spent on works in course of execution) amount to £2,500,000 or twice the total funds available annually. It is in consequence necessary to put aside annually as a first charge about £1,000,000 out of the £1,250,000 for the further development of what are known as "Continuation Services." It will again be clear to you that as a result, firstly, new commitments can only be undertaken as existing commitments die out (*i.e.*, as works are completed): secondly, that only a comparatively small sum can be available for any command schemes, however desirable they be. However, you will notice that this does constitute a reserve.

PART I. E. & M. SERVICES.

Even out of the assumed quarter-million left over from continuation services, there are certain capital services falling under category B (production of electric light, water, etc.), which must have first choice, either from the necessity of expansion to meet requirements of increased camps, or because modernisation is essential to reduce annual expenditure. As this latter matter is one of importance very imperfectly understood even by the R.E. themselves, I must devote a few words to it. In the past:—

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(i) As barracks have expanded, there has been an opportunist tendency to put down an engine here for pumping water, another there to pump sewage, a third to generate E.L., a fourth to provide power for a workshop, etc. Now with machinery, as with other efforts in life, economy lies in concentrated effort (mass production).

(ii) Mechanical science again has made vast strides since the war, perhaps largely due to such economic causes as increased costs of labour and fuel. Whereas prewar and war steam engines for generation of E.L. might consume from 35 lbs. to 50 lbs. of steam per k.w. per hour, modern steam plant consumes only 15 lbs. Any expansion of output then is a proper occasion to consider the installation of modern plant, after full investigation of the future annual costs of operation. Such considerations as these involve reference back to commands of their proposals of Part I Services and, I fear, some chafing at our insistence on full considerations being given to these economies.

Part I. Central Control.

Finally as regards these Part I Services, I would observe that not only is financial control exercised in some detail even by Parliament itself, but even as regards designs, specifications and contracts, very little responsibility can be devolved on to the executive: these are prepared in the War Office for all the more important services, and the executive is charged only with the responsibility for ensuring that the contractor executes the work in accordance with the designs, specifications and terms of contract.

Part II. Services.

Now let us turn to the Capital Services which cost under £2,500 and you will see a very different picture. You will notice that a lump sum of about £250,000 is voted by Parliament under Head V.B.2 of the Army Estimates. Speaking broadly, this is divided up by the War Office and allotted in lump sum to commands. The only restriction imposed is that services costing over £300 must receive W.O. sanction. The principal reasons for this are to ensure that :—

(i) There is no attempt to carry out a Part I Service by cumulative Part II items.

(ii) To ensure that such expenditure will not be rendered nugatory by some policy or programme not yet entirely formulated and therefore not yet disclosed to commands.

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The *modus operandi* between W.O. and commands is as follows :— In the " Statement of proposed services "submitted to W.O. in September to enable Army Estimates to be compiled, " Command " schedules various items estimated to cost between £300 and £2,500 and in addition asks for a lump sum (based on average expenditure of preceding years) to cover expenditure on services under £300. After Army Estimates have been approved or (say) about the beginning of the following April, W.O. will in effect reply " Here is £30,000 : of the items over £300 enumerated by you, such and such items must not be executed : such and such items will be executed : the remainder may be executed if you still wish to do so, and can spare the funds : in any case after executing the items we have told you to execute, the balance of the £30,000 is at your disposal." The M.G.A., in his turn, writes to areas " Execute such and such items for which I herewith allot you so much : I also allot you £ . . . . . (let us say £3,000) for any minor items you may see fit to execute, with the proviso that you must obtain my sanction to any one item over £200."

PART II. CLASSIFICATION.

I do not wish to confuse you but should at this point interpolate that as regards these Part II Services, they are sub-divided into :—

Barrack Services,
Fortification Services,
A.O.D. Services,
Hospital Services,
Telephone Services,
Mechanical Services,
W. D. Estates.

The restrictions imposed on the last six are far more stringent : in effect they are all decided at the W.O. somewhat similarly to the methods previously stated for Part I Services, the reasons being that policy as regards these six matters cannot well be left to local views.

PART II. USE OF LUMP ALLOTMENTS IN DISTRICTS.

Reverting to consideration of the lump sum for minor services which reaches a C.R.E. and his commander, and we have assumed to be in the region of £3,000, it is here that the closest co-operation and appreciation of each other's work can result in the greatest benefit to the local military community as a whole. Especially in some of the older barracks, considerable improvements in the convenience of administration and in the comfort of the troops can often be effected by well-considered schemes of *re-appropriations*

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at surprisingly low cost. In the case of defensive barracks, these often have surplus accommodation, some of which can be converted to dining rooms or lecture rooms or corporals' messes. It is advisable however, to avoid re-appropriations of an opportunistic nature and to think out a scheme for a general re-appropriation, which will really modernise the barracks when you add proposals for new constructions, such as the addition of sanitary annexes and other extensions. You can then put it forward as one whole Part I scheme for modernisation of X barracks; but you will have more chance of getting on with the scheme if you cut it up into such separate re-appropriation proposals and other items as can legitimately be done as Part II Services, *e.g.*,

(i) Re-appropriations which require W.O. sanction and special allotment of funds by W.O.

(ii) Re-appropriations which require W.O. sanction but can be done with local funds.

(iii) Re-appropriations which can be approved by M.G.A. and can be done with local funds.

(iv) Additions or extensions which do not involve re-appropriations, and can be done with local funds.

(v) New construction involving Part I expenditure.

To get (i) and (v) will, for reasons which I told you (under Part I), be a matter of time: but if you make the other re-appropriations separate schemes and are prepared to find the funds from your bulk allotment, approval can usually be obtained with reasonable rapidity. You must, however, realise that it is not permissible to execute any one service as a series of Part II Services in succeeding years, if the aggregate of these annual expenditures amounts to Part I Service. You may not build walls and roofs in one year and then put in floors, etc., in the next, if the aggregate cost exceeds the limit of your authority for initiating expenditure.

Part III. Services.

The principal expenditure of a C.R.E., however, is incurred in maintaining W.D. properties in efficient repair: buildings, roads, training areas, telephones, installations, fences, etc., and this is a costly business: any one C.R.E. may be responsible for expenditure on maintenance amounting to from £50,000 to £100,000 per annum.

Before going further, I must emphasise that it is a financial crime to expend any of this money on new services. It is not always easy to get commanders to realise this: I hypothesised a Part II allotment to a district, of £3,000, but M.G.A. may prefer to centralize control of Part II expenditure to a greater extent and may only allot, say, £1,000 to the unfettered discretion of the local commander.

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It is difficult sometimes to understand why a service costing, say, £150 cannot be carried out when you know that C.R.E. has £50,000 to spend. Please realise that this £50,000 is definitely allocated to maintenance and maintenance only. In effect the whole of the Part III funds voted by Parliament are passed on to C.R.E's as lump sum allotments, although a minor portion may not be sent out at the beginning of the year but may be kept back for emergencies arising from fire and storm, etc.

PART III. PROGRAMMES.

Efficient maintenance demands careful organisation and programmes which look years ahead. Methods will vary with the character of the C.R.E. and his D.O's, and control must on the whole rest on careful inspection by superiors. There is much which could be said, but there is no time now to dilate on the subject, nor is it very essential that you should study it, though there is nothing mysterious about it—it is hardly even technical, it is a matter which you may reasonably leave to your R.E. without undue anxiety. But the elementary principles for a C.R.E. are :—

(i) Put aside specific sums for periodical repairs, *e.g.*, painting, renewals of roofs and floors, roads and fences. Painting alone may absorb from 25 per cent. to 35 per cent. of the maintenance funds: and you can understand how a definite painting programme can be arranged on an 8-years' cycle, on the basis that every building must be painted externally once in 4 years, internally once in 8 years.

(ii) C.R.E. will name some special services which he desires to be executed and will allot funds for those.

(iii) He will allot the balance of the money as lump sums to his D.O's.

D.O.R.E., in his turn, will sub-divide his lump allotments, allocating part of it to cover the cost of repairs noted as necessary at his quarterly, etc., inspections, and part to cover the cost of men employed on routine maintenance and urgent repairs.

PART III. URGENCY.

It is necessary to keep a few such men in a directly employed gang in order to meet demands for urgent repairs. Whilst, admittedly, the stitch-in-time may actually save nine, there is a natural human tendency on the part of D.O.R.E. to oblige local commanders and staffs by executing with such gangs minor services which are not really urgent. This results in increase of the gang; we cannot take on artisans *de die in diem*, and it is not always possible to employ all such men on important work: there is always a tendency towards " finding " work for some of them from time to time. This

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spells waste: you should therefore curb any tendency on the part of yourselves or of those under your control to put in "urgent requisitions" for repairs, which are not in fact urgent.

Control by Cost Accounts.

In the control of Engineer Services we have welcomed cost accountancy and have agreed with finance and accountancy branches forms of account which serve the dual purpose of army accounts and of engineer control—thus obviating many of the returns formerly required.

Devolution.

Properly applied, cost accounts should render possible greater devolution of responsibility and allow more freedom in administration to subordinate administrators. To the superior they afford reliable comparative statistics, which will reveal at once, when read by men accustomed to their use, whether, and if so where, waste is taking place. Thus they should enable superiors and auditors to take wider views and to free themselves from meticulous detail. May I take this opportunity to interpose a few words on control by regulations and audit.

"*R.E.S.*"

The regulations (*Regulations for Engineer Services*) which govern the execution of Engineer Services, are only intended as a guide to principles. It is fully recognised that we cannot make regulations to govern every circumstance which may arise, nor would it be proper or desirable to attempt it.

Audits.

An officer who understands and honestly endeavours to apply the principles inculcated to the best advantage of the public service with zeal and energy, has nothing to fear from superiors or from auditors. Audit is not carried out in any spirit of carping criticism, based on the letter of regulations, but with the wide view of ensuring the absence of fraud and the prevention of waste. Engineering experience is apt to reveal strange sides to human nature. When you appreciate and learn to allow for these factors, you will learn to understand better the outlook of auditors and financial advisers. You will also find them ever ready to help you through what may often appear to you to be terrifying financial morasses.

Sometimes you may think finance branches are obstructing your path: but remember that their aim is to prevent scandals, rather than to smell out crimes, and that financial scandals may and do result more often from ignorance, or sometimes from negligence, than from any actual fraud. Negligence of accountancy control by any of us may tempt some subordinate to his ruin.

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CONSTRUCTION ACCOUNTS.

What we all want, then, is the simplest form of accounts which will reveal at once to our limited knowledge of financial matters whether there is a need at any point for a tighter rein. Hence the Engineer Construction Account. This R.E. keep for themselves, with the aid of the C.M.A.

Now let us examine this account and see how it can be used for control. See also the accounts for operative installations and comparative statistics which we get from them.

ENGINEERING AN AUXILIARY TO INFANTRY.

In conclusion, may I say a few words as regards the use of the Engineer Arm. Like other auxiliary arms, and all auxiliary services, its *raison d'etre* is, in common with those others, solely to assist in getting the infantry of the attack at the decisive moment to the decisive point, in the best possible condition as regards morale, minimum of loss in the advance to the attack, and maximum of efficiency of equipment and health. Whatever may be advisable as regards aid to this end, a final decision has never yet been attained, and I believe never will be attained, otherwise than with the club and the stabbing weapon. Since the war we have been somewhat deafened by the babel of enthusiasts who regard their own pet weapons or scheme as the one method of defeating an enemy. If they were all listened to, there would be few or none left to form the infantry phalanx: it would be analogous to the attempt to cool water in iron tanks by evaporative processes. It is quite effective, but is apt to leave no water to cool. Some talk about an Engineers' war; I do not know what they mean: land war is an infantry war; in effect all the aid given by auxiliary arms and indeed services involves some form of engineering: but because you label a man as an engineer, it does not mean that he is competent technically to control or direct every conceivable form of engineering at one and the same time. If indeed such a man exists, he must be a man of such superhuman talent that he could be spared for no subordinate post. Probably the higher the administrative position, the less is it desirable that the holder should know too much detail; otherwise he may and usually does fail to see the forest for the trees. The control of technical services should therefore at some point in the chain of command focus in administrators, preferably with staff training; it is, however, in that case necessary that such an administrator should know sufficient of the general principles which govern the work of the services that he may understand the advice of the technical heads, appreciate the difficulties, and hold a due sense of proportion. It is with a view to giving you some such insight into the technical work of the R.E. that I have directed my remarks in this lecture.

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NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-1918 (*continued*).

By BRIGADIER-GENERAL W. BAKER BROWN, C.B.

DETAILS OF ENGINEER WORK.

I now propose to consider shortly some details of the actual work carried out in the Eastern Command during 1915-16. These can be divided into three large groups—

1. Work carried out for or in conjunction with the General Staff.
2. Work carried out for or in conjunction with the Q Staff.
3. Work carried out for or in conjunction with the Medical Staff.

WORK FOR AND WITH THE GENERAL STAFF.

Coast Defences. The first work to be considered is that connected with the Coast Defences. These gave comparatively little trouble, as the details connected with manning are all worked out beforehand. The local officers, therefore, knew exactly not only what they had to do, but how to do it, and the manning of the electric lights and the installation of the necessary additional telephones were a matter of only a few hours.

But a few words may be allowed for an appreciation of the excellent work done by the Electric Light mannings. These consisted, on the outbreak of war, of a weak R.E. unit at each port, which had to be completed with local territorials, and where the latter did not suffice, with detachments from the London, Tyne or Liverpool Electrical Engineers. During the progress of the war these manning details were drawn on again and again to form detachments for search lights for field service or for anti-aircraft defence, and were replaced by newly-trained men from the headquarters of one of these three units. Many additional lights were also installed during the war, for which manning details were provided. The material stood the strain of the prolonged running remarkably well, and during the whole period of four years and three months, the lights were run in all conditions of weather, and with a complete efficiency which could hardly have been bettered. From the nature of the work no notice appeared in the Press, and, as far as I know, no reference has been made to it in any of the books on the war. And yet the quiet steady manning of the Coast Defences by the R.A. and R.E. was one of the essential factors which kept the enemy from our shores, and allowed us to send overseas those magnificent armies which brought the war to a conclusion.

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Additional gun defences were added during the war, but these were designed at the War Office under the supervision of Col. H. V. Kent, R.E., who made all preliminary arrangements for their execution. The Command had the responsibility of getting the work done.

The land defences of the Coast Fortresses did not differ in kind from the ordinary field defences, except perhaps in the case of the defences of Harwich harbour, where conditions arose which provide a warning for the future. The north side of this harbour is formed by a long sandy spit, on the north of which is situated the town of Felixstowe; north of this town there is the ordinary undulating country. In considering the position to take up for the land defences, the General Staff at the War Office found themselves on the horns of a dilemma whether to include Felixstowe in the defences or not. If they drew the line of defences south of the town, the line became very short, but a hostile landing force in occupation of Felixstowe would have made it very uncomfortable for the occupants of the permanent defences at the south end of the spit. On the other hand, if the line of defence was carried north of Felixstowe it would become much longer, and would require a larger garrison, and absorb more men than the General Staff were then prepared to allot. The final decision lay between these two extremes, and was to occupy an intermediate line on a small ridge running right through the centre of the town of Felixstowe. On the outbreak of war the local D.O.R.E., in pursuance of this scheme, commandeered a number of dwelling houses, putting some in a state of defence, and demolishing, or partly demolishing, others. Claims for damages were at once made which soon exceeded £40,000 in value, and when these reached the War Office two special valuers were sent down to assess the damage, and were at work when I joined the Command. Soon after, it was decided to construct additional batteries to the north of the town. This necessarily involved the occupation of the outer line of defence, and finally a complete Reserve Brigade was allotted this part of the defence instead of a single battalion.

Anti-aircraft Defence. When I joined the Command I naturally enquired what was the position as regards anti-aircraft defences, and was told the schemes for these were all prepared at the War Office, and that our responsibility was limited to the actual erection of guns and lights and accommodation for their personnel in named positions. Early in 1915, raids by Zeppelins were being carried out on the various naval and military establishments in the Thames Valley, but none of these had reached London, where the only defences were the naval guns and lights organised by Admiral Sir Percy Scott.

On some date in May, 1915, I happened to be motoring on duty with a member of the General Staff of the Command, and he told

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me that in a raid the previous evening one of the military establishments had been hit by a bomb, and asked if I knew anything about anti-aircraft defence. I was able to reply that I had had rather unique opportunities of studying the working of guns and lights in connection with coast defences, and that when on half-pay two years before I had attempted to work out some principles of defence against aircraft, and I had contributed a short article on the subject to a military paper.

As a result of this informal conversation, on returning to the office, I was asked by the head of our General Staff—Col. A. Hinde, R.A.—to explain my views to the C. in C., Sir Leslie Rundle. I pointed out that in my opinion our anti-aircraft defences suffered from two main defects: first, the attempt to allot each light to a particular gun or guns, and secondly, the concentration of the defences in the area of the dockyard or establishment to be defended, so that the enemy had only to drop his bombs among the lights to have a very good chance of hitting a vital spot. I therefore suggested that better results could be obtained if the defence guns and lights were distributed over a much larger area surrounding the establishment to be defended, so that they could engage the enemy *before* he reached his objective, and that the defences should be fought as a whole on the principle that the lights should search for and find the enemy aircraft, and that the guns should then engage the enemy while illuminated, without troubling as to which light was doing the illumination. Sir Leslie Rundle took the question up with his accustomed energy, obtained the support of Sir David Henderson, who was the head of the Flying Service at the War Office, and got permission to alter the defences. He appointed an executive Committee of Col. Hinde and myself, with Lt.-Col. Molony, R.A., as Secretary, and we began systematically to revise the whole of the Thames defences. On considering the experience of attacks up to date, two points were worthy of notice, the efficiency of the lights used and the inefficiency of the guns. There was at this time no regular equipment of lights for field use, but we had been able a few years before to get a field searchlight company formed at Aldershot which carried out experiments, and in connection with these we had elaborated patterns of light projectors, cables, and other details. Although this unit was not included in the Field Army establishments, the experience gained was of the greatest value in preparing the lights required for anti-aircraft defence. But these lights were of a small size, and our experience with coast defence had shown that such lights would lose much of their power at a range exceeding 1,500 yards (or 4,500 feet). We were, therefore, at first surprised to find the lights giving efficient illumination at heights of 9,000 feet and over. A little consideration showed that the difference was due to the fact that evening mist or fog—the

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great enemy of searchlights—is heaviest in the lower levels of th atmosphere, so that lights used for coast defence have to conten with mist throughout the whole extent of their range. If, howeve such lights are turned upwards, the layer of mist is only abou 100 feet thick, or less, and there is little interference. In practic the two-foot projector proved quite effective at ranges up to 5 mile and heights of 12,000 feet.

While, however, the lights were working better in a vertica position, the guns were very adversely affected by the altered con ditions, as few guns at that time were capable of an elevatio approaching 90° from the horizontal. We found also the armamen allotted by the War Office included pompoms with a maximun range of about 3,000 feet and 6 pr. guns with a maximum elevatio of 60° and a maximum effective height at the highest point of thei trajectory of 6,000 feet. When the defences were first arranged i was thought that the enemy must come down to 6,000 feet in orde to place his bombs with accuracy, but our limited experience at tha date showed that the usual height of attack was 9,000 feet, and a our defences got more efficient the attackers kept at 12,000 fee or over. The naval defences of London were worse off than our selves, as their guns were of old naval type and some not even fitte with a deflection leaf on the sights.

Our Committee got to work at once, rearranging and siting th best of the guns and lights and adding more as the War Office wa able to supply. We brought Purfleet, where the defences had bee installed by the London District, within our sphere of operations and as defences were added at various manufacturing centres, suc as Enfield and Dartford, they were linked up with others, until w had practically a continuous defended area from Faversham in Kent, covering the whole of the lower basins of the Thames and Medway.

The effect of our work was very marked. Instead of using th Thames as a guide, helped by the pillars of light at certain definit points, the enemy found himself met by a network of lights, pickin him up and following every movement, till he did not know where he was or where he was going. He had in short " lost the Thames." Towards the end of 1915 he appears to have definitely abandoned this line of approach, and though he continued his raids—making land on our East Coast and following the railways to London— whenever he met our defences he was forced to high altitudes of 12,000 feet or over, from which he could not drop his bombs with any accuracy. Although the fixed defences could not stop raids they had made them increasingly difficult and hazardous.

In September, 1915, I was called to the War Office, where I was shown a scheme for applying the principles we had advocated to the defence of London itself. In pursuance of this it was proposed

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to place a ring of about 30 guns and 30 lights in the suburbs, to be followed by an outer ring as material became available. These defences were to link up with those at Enfield and Woolwich. Sites had been reconnoitred by officers from the War Office, and as the defences were to be kept well away from the centre, which was covered by the naval guns, all these sites came within the area administered by the Eastern Command. Most of the work fell on my C.R.E's at Woolwich and Hounslow, and was carried out efficiently and quickly.

At the same time our Committee rearranged the anti-aircraft defences of the defended ports, and many outlying places where ammunition was being manufactured were allotted defences.

When the G.O.C. Home Forces was appointed, Col. Sir E. Raban (late R.E.) was attached to the General Staff, Home Forces, as an R.E. adviser, especially for anti-aircraft defences, and after he had studied our methods gradually took charge of new schemes, while a special C.R.E., reporting directly to those H.Q., was appointed later to carry out the engineer work connected with these defences. So that before I left at the end of 1916, the C.E. Eastern Command was relieved of much of his responsibility in this connection. During 1916 much progress was made in range finding and in the shooting of anti-aircraft guns, while the defences were reinforced by mobile guns and lights and by special air squadrons, for whom a series of landing grounds had to be prepared. During this year these combined defences were successful in bringing to earth four Zeppelins and practically in breaking up this form of attack, though one more attack on a grand scale was made the following year.

Training Grounds and Rifle Ranges. The provision of training grounds for the troops calls for no comment, as any land required was easily obtained by our efficient Land staff.

For rifle ranges the War Office had early secured the services of Col. J. H. Cowan (late R.E.), the well-known rifle shot, and he became the head of an organisation for selecting and constructing rifle ranges all over the country. The Command had little to do with these (except land services) until the ranges were completed, when they became responsible for maintenance and for the supply of targets and accessories.

At first the full length ranges were little used, as there was no ammunition to spare for the purpose. In fact in May or June, 1915, a whisper went round the office that in the whole of the ordnance depots in England there was only one box of rifle ammunition remaining. But later, when ammunition became more plentiful, the new ranges were very largely used for training the new levies.

Each new hutment was supplied with covered miniature ranges, and these were also provided in connection with hired buildings.

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Telephones. As already explained, the actual work on telephones was done by the G.P.O., so that our duty was limited to notifying the P.O. of the requirements of the Command.

Flying Establishments. Although the first flying establishments were constructed with a view to training, they were soon brought into our defence arrangements, so that they are best considered in this part of these notes. On the outbreak of war two permanent establishments for the flying service were under construction in the Command at Dover and Orfordness. At Dover the scheme included a complete set of barracks, which were being constructed by the Director of Barrack Construction. The erection of the hangars and preparation of the landing ground came under my C.R.E., and most of the work was done after the outbreak of war. At Orford it was intended to form an experimental station, but the work was delayed by the absence of water supply. A deep bore had been started by the War Office, but failed to find water at 900 feet. The preparation of the landing ground, and the erection of hangars and huts was pressed on after the war started, so the provision of water now became urgent. Barring a supply on the spot, the only possible sources were to draw on the town of Aldeburgh, which would necessitate the laying of several miles of water mains of a large bore, or the obtaining of water from the village of Orford, which was close to the site but separated by a salt water inlet 600 feet wide. Geologically Orford is one of the most interesting spots in England, as it is situated on what is known as the Coralline Crag, which is, I believe, the most modern deposit known in the British Isles. The Coralline Crag is a very spongy sandstone, and has the property of holding an extraordinary quantity of water. A hole dug down a few feet soon fills with water, and the inhabitants, in addition to drawing their water in their own gardens, also use this property to get rid of the sewage, which is run into cesspits sometimes only a few feet from the water supply. Having decided to utilise this source of water, there was no difficulty in selecting a suitable site as far from houses as possible, in erecting a suitable pump and constructing a shallow well. The practical difficulty had then to be faced of getting a four-inch main across the salt water inlet, and after some discussion I suggested that the method used for landing shore end cables might be suitable, the pipe being jointed on shore and floated across the estuary attached to casks or floats. Fortunately the depth of water was small, so that the curve in the pipe was not more than would be taken up by the spring of the metal. The job was finally done on these lines by a Field Company of Lancashire Engineers which was quartered in the neighbourhood.

In addition to the permanent aerodromes, a number of temporary establishments were constructed of which the best known are those at Northolt, Thetford, Hounslow and Lympne, the latter being the

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first constructed for the larger size machines. By the end of 1916, establishments had been completed in the Command for fifteen squadrons. The establishment for each squadron consisted of three aeroplane sheds, with auxiliary shops, transport sheds, and a hutment for about 250 officers and men. The total cost was about £25,000 per squadron, a figure which represents a startling contrast to the figure later on in the war, when the cost of an establishment on a rather larger scale reached £250,000. The details of aeroplanes have changed so much that our experience of ten years ago is now out of date, but I may mention that many of our difficulties centred on two points, the roof span and the nature of the flooring. The roof span of the first sheds erected was fixed at 65 feet, and this was increased later to 80 and then to 90 feet. These spans had to be bridged by wooden trusses, a Kingpost construction being used for the smaller span and a Belfast girder for the larger. For the floors of the sheds we went to the Road Board, who laid tar macadam and also formed a macadam apron round the entrance to each shed.

The plans for the establishment and all the detailed reconnaissance of sites were arranged by a special branch of the D.F.W's office under Col. W. Macadam, R.E. The Command had the responsibility of arranging for construction and maintenance.

Towards the end of 1915 it was decided to allot some squadrons for the defence of London. These were divided up into "flights," and for these we had to construct a string of 30 landing grounds in Suffolk, Essex and Kent. As these were selected partly for strategical reasons, we had to overcome some difficulties of construction. Each landing ground had to be lit at night and to be ready to administer "first aid" to any aeroplane landing, so that a small group of huts was required in each case.

Bridge over the Thames. Mention may be made here of the road bridge over the Thames at Gravesend, though this did not give much work to the staff of the Eastern Command. The object of the bridge was to provide a road passage over the Thames, which would avoid the roundabout route through London. The design followed the principle of our pontoon bridges, but the floats were formed of ships of several hundred tons burden and the baulks were massive baulks of timber. A cut 600 feet wide was formed of three ships with superstructure. The work was designed and executed by the Port of London Authority under the supervision of the C.E. Thames and Medway Defences, and the same authority arranged for maintenance and provided tugs to attend to the "cut." They also controlled the traffic in and out. A model of this bridge is preserved in the R.E. Museum at Chatham.

(To be continued).

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"*FULMAR*" *IN THE OCEAN RACE.*

By CAPTAIN R. M. H. LEWIS, M.C., R.E.

Fulmar has been sold, and in a few years, like her predecessors, will be only a memory to members of the Corps. So many R.E. officers have managed in the past to forget Chatham and its iniquities while cruising in her that it is thought that an account of her last and most important race might be of interest, coming as it did as a climax to her best racing season in which she managed to carry off the laurels in two of the chief handicap races for small cruisers—the Burnham-Ramsgate race and the " Round the Isle of Wight " race.

The following account of the race over a 600-mile course, from Ryde, leaving the Isle of Wight to starboard, to the Fastnet rock off Cape Clear and back to Plymouth, is an amplification of *Fulmar's* log and has been reprinted in the *Yachting World.*

A perfect summer evening and almost a flat calm; the glass hitting the roof; six Sappers in high spirits, and only the inevitable hectic hour or two left to stow the remaining gear.

Such was the situation on the evening of Friday, August 14th, when *Fulmar* let go a cable's length west of Ryde Pier. The ship had been completely victualled at Gosport that day, the water tanks filled, and as many empty bottles as possible filled with water and stowed away. It was extraordinarily fortunate that a faulty inlet pipe to the starboard tank was spotted on watering at Gosport ferry pontoon, as a large amount of our limited supply would certainly have been lost when the ship heeled over. The leak was stopped by some rapid work with a soldering iron by the skipper on the trip over to Ryde.

Little remaining to be done on board, it was unanimously decided that a final dinner on shore was indicated, " to save the water supply." *Fulmar* was therefore abandoned and the entire crew turned in a few hours later as fully victualled as the ship herself. A visit to the Royal Victoria Yacht Club in search of sailing instructions proved barren of results, as the starters themselves apparently had, up to then, been told as little as we had, and only knew what we knew ourselves, that the race would start at 12 noon on the 15th.

The slight difficulty of fitting six people into five bunks having been satisfactorily solved by the simple process of the first five on board getting into the bunks, we awoke to find a glorious morning and a light easterly breeze.

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"FULMAR" IN THE OCEAN RACE.

R.E.Y.C. Cutter "FULMAR," 14 tons.
Second in Ocean Yacht Race, 15th to 22nd August, 1925.

Crew:—Lieut N. A. Blandford-Newson (Skipper), Lieut. H. D. Bennett (Navigator).
Hands:—Capt. R. M. H. Lewis, M.C., Lieuts. G. L. Watkinson, H. A. Macdonald, and P. L. Wilkinson.

Photograph by Beken & Son, Cowes, I.W.

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excitement of which the fact that the jib-topsail sheet needed hardening passed unnoticed.

The light easterly wind gave us a beat down Spithead, and on bearing away for St. Catherine's we found ourselves third to *Gull* and *Saladin*. The spinnaker was set to port and fairly good progress was made, but off Sandown *Jolie Brise* romped past us under an enormous running sail which turned us green with envy. This left us fourth, with *Banba*, *North Star* and *Jessie L.* well astern. The wind dropping lighter and lighter, we appeared to hold our own with everyone except *Jolie Brise* and possibly *Gull*.

At 2.15 p.m. we passed St. Catherine's and set a course W.¼S. for the Lizard. Shortly afterwards we caught *Saladin* and kept company with her until dark. We were grateful to her crew for giving us the wireless weather report, but it did not sound very cheerful. Our companion edged to the southward during the night, and catching a light breeze, went away from us, leaving us cursing light variable airs all night and the next morning, the 16th. By this time we were organised into three watches of two, which we decided to stick to while the weather remained light. The watch next for duty was detailed to prepare the necessary meals, and the watch on deck washed up. This arrangement permitted the maximum of sleep for all hands and worked very well, though navigational activities occasionally necessitated assistance in washing up. The necessity of washing up in salt water, due to our limited water capacity, was rather trying, especially after breakfast.

The evening of the 15th saw our first and only casualty, the inevitable flare-up with a primus causing a badly burnt hand and nearly setting the head-sails on fire. The night of the 15th was uneventful with Portland Bill light showing up clearly and much shipping about. Little progress was made. A beautiful dawn on the 16th revealed to our joy our three rivals still in sight ahead, *Saladin* nearest, *Jolie Brise* ahead of her, and *Gull* hull-down. Considering the enormous advantage in the matter of light-weather canvas that these ships possessed over us, we were well content to have them still in sight. Of the ships astern only *Banba* was visible, hull-down. The beautiful dawn degenerated into an airless and broiling day with our rivals gradually drawing ahead. So little progress was made that bathing was indulged in quite safely, the clear blue water of the Channel being a pleasant change from the soupy compound of the Medway.

A light breeze coming up from the N.E. about 2 p.m. cheered us up considerably and sent us along at about four knots, with spinnaker to starboard. At sunset a last look round revealed *Saladin*, *Gull* and *Jolie Brise* hull-down, and that was the last we were to see of them for some time. The breeze freshening a little, we had Start Point abeam at 12.30 a.m. on the 17th. A steadily falling glass filled

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us with hope that the longed-for stiff breeze was coming, a hope, alas, not realised for many tedious hours yet. The day of the 17th dawned with overcast sky and still that steady, hopeful dropping of the glass, which had now dropped over two-tenths since leaving Ryde. The visibility having deteriorated considerably may account for our failing to sight our leading opponents at that time.

Land on the starboard bow at 1.30 p.m. was, after slight navigational argument, mostly facetious, at the expense of our hard-working skipper, located as the Lizard, and at 3.30 p.m. we gybed once more and altered course N.W., running through a number of the picturesque Cornish luggers.

7.22 p.m. saw us take our departure from the Runnelstone for our run to the Irish coast with the log streamed. If the wind remained steady we had high hopes of sighting once more the leading ships. *If* the wind remained steady: precisely the one thing it did not do throughout the first five days of the race. It seemed as if the elements were taking a hand in this race and enjoying it thoroughly.

The night of our departure from the Runnelstone saw us in a flat calm, once more, before 10 p.m., with a thick fog and a certain amount of shipping to add to the fun. Our mechanical horror of a fog-horn was produced, and sleep rendered impossible for the next few hours by its energetic use. The horn seems to have disturbed other people's sleep besides our own, as a steamer approached nearer than was pleasant, evidently mistaking us for a pilot boat.

Dawn of the 19th broke with visibility still poor and the glass still falling, but with the wind dropping light and patchy, necessitating continual trimming of sails. Visibility improved later, and at 11 a.m. the watch on deck executed a short song and a dance and reported *Gull*, *Jolie Brise* and *Saladin* in sight about three miles ahead. They were, of course, told to take more water with it, but they had the last laugh, and the song and dance was extended to the rest of the crew some ten minutes later. The three leaders all had spinnakers set to starboard, while we were reaching on the port tack and rapidly overhauling them. Our good breeze took us right up to them and then left us as if to say, "There you are, you've had your share." Need it be added that our jubilation was unbounded at finding ourselves, three days out, in close company with the leaders, and our unknown handicap still in hand? It more than made up for the many hours rolling alone, with the booms guyed and the reef points beating their ceaseless and monotonous tattoo, and for the constant and seemingly useless trimming of sheets.

The breeze, before it left us, took us within hailing distance of *Gull*, with *Jolie Brise* about a mile ahead, and *Saladin* abeam but well to leeward. "Hailing" distance, be it noted. The neighbourly

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Gull tried to turn it into speaking distance. Most of *Gull's* crew bellowed at us and we shouted ourselves hoarse in return, but the word "what" was the only one distinctly heard for some time. *Gull's* log states that we told him that we passed the Runnelstone at 11 p.m., during the conversation; 7 p.m. was the noise we attempted to make. Owing to the lung-power required, conversation was languishing when *Gull* produced a hand with a remarkably clear speaking voice, suitable for drawing-room or fog-horn use. From him we learnt the handicaps, which were as follows :—

	Handicap.
Jolie Brise	scratch
Saladin	6 hrs.
North Star	6 hrs. 30 mins.
Gull	9 hrs.
Jessie L...	10 hrs. 40 mins.
Fulmar	12 hrs. 20 mins.
Banba	unknown

It appeared from them that, luck being with us, we need only fear *Gull*. We also learnt of *Gull's* ill-luck in carrying away her topsail halliard, for which we were extremely sorry. But for that stroke of ill-luck the chances are that *Gull*, on her previous and subsequent performance, would have won. Outbursts of melody followed the conversation from both ships; mercifully the distance must have slurred the noise we were making. The excessive state of drought produced by such vocal efforts turned our thoughts to a dip, but at that moment a large shark's fin appeared within three yards of the ship and, well, second thoughts are best. The skipper, hastily hurling his sextant to the deck, leapt below and returned with two large revolvers. The remainder of the crew having hurled themselves flat (they would have hurled themselves further but for the shark), he proceeded to indulge in some of the most execrable shooting we have ever had the misfortune to witness. The presence of the revolvers on board remains unexplained, unless it was in anticipation of a mutiny. From this echo of war, however, we were rudely recalled by the sight of *Jolie Brise* sailing away from us with a nice slant of wind which left *Gull* and ourselves severely alone. Right out of the middle of the fleet did that discriminating breeze take the scratch boat, and *Saladin* also got the fringe of it, leaving *Gull* and *Fulmar* rolling their masts out.

This was the deciding factor of the race, though we refused to recognise it at the time, and buoyed ourselves up with the thought of our twelve hours' allowance.

All the rest of that day and the night of the 18th-19th we remained becalmed; in fact, on more than one occasion the ship turned round in a complete circle. On the 17th we had begun to be

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seriously concerned with the question of water, as we seemed in for a long spell of calms, and as a precautionary measure cut ourselves down to 1½ pints of fluid per head per day, whether *aqua pura* or the bottled variety. It was then that we had cause to be thankful for that three dozen of beer. This limiting of liquid caused us no undue discomfort although the weather was broiling hot most of the time.

It was not until about midday on the 19th that we eventually got a light breeze from the west and went away closehauled at about 3½ knots, with *Gull* still in sight and *Saladin* just visible a long way to leeward. The glass continued its steady descent.

At 6 p.m. on the 19th we sighted the Irish coast, black against a yellow sky. This we made out to be Toe Head, and shortly afterwards Galley Head showed up. The *Fulmar* method of reading the log after long calms was then applied. As it is rather unique and highly scientific it is worthy of description. (*a*) First sight land. (*b*) Recognise it, if possible. (*c*) If you are skipper or navigator rush below with pencil, ruler and indiarubber and erase previous estimated position from chart, having first of all ascertained approximate bearing and distance from prominent shore object. (*d*) Insert correct position on chart and hastily measure distance from last land sighted. (*e*) Look up log reading and from this and real distance work out a percentage error for the log. (*f*) Insert small cross on chart at a distance from the correct position depending on the credulity of the crew. (*g*) Return on deck and inform the crew that the real position and the approximate position by dead reckoning coincide very closely. The game is suitable for one or more players, and is made more enjoyable, as was done in *Fulmar*, if one of the crew contrives to step on the log if it is left lying on deck at any time.

Another *Fulmar* pastime which was most enjoyable was the using of a sextant to check time and position. To be really enjoyed this must be done with the ship rolling heavily. Many hours can be whiled away estimating from your readings, and, provided an armed guard is put on the chronometer to prevent anyone altering it to fit in with the results of the observations, it is quite innocuous.

To return to more serious matters, a pitch dark night, a heavy swell and almost a flat calm found us with the flash of the Fastnet light showing up over the horizon. For this we made as best we could, puffs of wind coming from every direction. The strain of continuously trimming sails, gybing, and getting the spinnaker in and out with two-men watches was very severe, but the trouble taken was rewarded next morning as we gradually drifted round the lonely Fastnet Rock, with *Gull* a mile or so ahead and *Saladin* close astern. It must have been quite an event for the watchers on the lighthouse, this ocean race. "What ship are you?" "*Fulmar*."

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"When did *Jolie Brise* pass?" "7.30."—pause—another string of flags on the lighthouse—"Yesterday evening!" Groans from *Fulmar*. "Thank you." "I wish you a pleasant voyage." "Thank you!" So ended our conversation—and with it half our journey.

Round the mark—but only just. From the time of rounding until 11.30 a.m. on the 20th the only things moving were the seagulls and the glass—the latter accelerating its descent in a most cheering manner. *Gull* had edged in under the land and seemed to be going away slightly, but very slightly. *Saladin*, after standing well into Clear Island, caught a slight puff and began to overhaul us. We on *Fulmar* had time to admire a very beautiful shore and a coast which must surely be a yachtsman's paradise. But for the monotonous chant from the two junior members of the crew of "every day in every way it blows harder and harder." it would have been hard to imagine a more peaceful scene: not that we wanted peace just then with *Jolie Brise* twelve hours ahead. At about 11.30 a.m. the disciples of M. Coué hailed with triumph the advent of a light breeze from the west at last. It arrived only just in time to prevent *Saladin* overtaking us. This longed-for breeze continued to freshen every minute, and our spirits went up as the glass went down. 12.30 p.m. saw a fresh breeze from the south-west, the Fastnet dropping astern, and a jubilant crew *racing* at last, and making the most involved and hypothetical calculations as to how many hours we were going to hold the breeze before *Jolie Brise* got it. In our relief it is to be feared that we rather overdid the racing business, with the crew aft on the counter, and a pull here and a pull there as if we were racing a metre boat in the Solent. It was the spirit of the thing which counted, however, and it keyed us up to the right pitch for the somewhat strenuous run home, a run which, it seemed, would determine the first four places perhaps only by a matter of seconds. The results at any rate, were encouraging, as we appeared to be dropping *Saladin* slightly and were certainly holding *Gull*. The spinnaker was stowed below as the wind backed, and we set our course S.E. for the Longships. By 3.30 p.m. there was a grand sailing breeze, marred only by the black rain clouds gathering to windward, with the prospect of a fresh-water wetting to come. For the first time in the race spray was coming aboard, and the donning of oilies in the near future seemed probable. Old *Fulmar* was doing her seven to eight knots as far as we could make out from the patent log which had more or less given up the ghost.

By 5 p.m. the lee rail was just awash and the jibtopsail was taken in; the threatened rain arrived at the same time and amply fulfilled its early promise. Until we neared Plymouth we were now only to see our two immediate neighbours at intervals between rain

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squalls, which came down with some violence and increasing frequency. Just before dusk the only defect in *Fulmar's* rigging developed, the hook of the weather runner starting to open out under the strain. This necessitated luffing and substituting a shackle, an operation which allowed *Saladin* to gain considerably. It was indeed fortunate that this defect was discovered before dark, as if the hook had gone later the consequences might well have been unpleasant. These hooks were only fitted to the runners just before the race, in order to save overhauling the runner tackles every time the main sheet was eased. Just before dark it was decided to take down the jackyarder, to which we had stuck all day, as it seemed to be setting in for a dirty night. This operation was successfully accomplished with the aid of a hand aloft, though it took some time with the sheets to leeward. The night developed into one of pitch darkness, with heavy rain squalls and a rising though still comparatively short sea, and the glass still falling rapidly. At 10 p.m. a three-man watch was set for the first time, and the remaining three turned in to get what sleep they could. The chief difficulty in obtaining sleep was the large amount of water which was by now finding its way into *Fulmar's* innards, mainly through the cabin skylight. Blankets and spare clothes were soon soaked, and going on deck was merely exchanging one form of damp for another. At midnight, as the wind was freshening still more, it was decided to take in three reefs, for which purpose the ship was hove to for a short period and all hands were turned out. In order to balance the ship, the staysail had to be lowered also.

It appeared later that it might have been more politic to have eased sheets only, as the squall did not last more than an hour, and before dawn the watch on deck succeeded not only in shaking out the reefs, but also in setting the staysail, jackyarder and jib-topsail once more—a feat performed without turning out the watch below, and one entailing a certain amount of labour even in broad daylight, with only three hands on deck.

Dawn of the 21st broke with the wind slightly eased, with the same unpleasant succession of black rain squalls coming up. *Fulmar* had opened up slightly, necessitating about ten minutes' pumping with the world's worst pump every three hours or so. *Saladin* showed up about two miles to windward; she appeared to have reduced sail considerably. *Gull* was eventually spotted between rain squalls about three miles ahead, but owing to the bad visibility she was rarely seen. In addition, by this time a considerable long swell had got up, and it was a question of taking a hasty glimpse round for her on the crest of a wave before we sank into isolation in the trough. During the morning the clew of the jib-topsail blew out, and it had to be taken in pretty quickly before it flapped itself to shreds. It was immediately repaired, but wasn't actually set

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again till next day. About midday the wind piped up again, and all hands succeeded in hauling down the jackyarder much more easily than the previous evening.

About 1 p.m. the breeze, which had never been very steady from the south-west, started to back until we were close-hauled with no hope of weathering the Longships without a tack. We must have been somewhere near the centre of the depression about that time, as a period of comparative calm was followed by an extra fierce squall and what appeared to be a small water-spout passed us about a mile away. We were now getting in the track of the steamers, necessitating a sharp look-out in the poor visibility conditions, but none came unpleasantly near. At 2.30 p.m. we sighted land, and soon afterwards went about on the port tack, our example being followed by *Saladin*. We were then some seven miles off shore, just clear of the foul shore tide. At that time we caught one more glimpse of *Gull*, much closer in shore, and, we thought, probably up against a much stronger tide than ourselves. We had now practically a dead beat for the Longships, with the wind varying a point or so either side of south. We made the distance in a series of relatively short tacks, putting the ship about to suit the vagaries of the wind. Thereby we managed to draw right away from *Saladin*, which apparently stuck on to the port tack and was headed right off. Perhaps this was how we also left *Gull* behind, but we were unable to see exactly what she was doing.

The Longships light was passed at about 8 p.m., after which the wind gradually backed right round in the most amazing manner to give us a beam wind right into Plymouth Sound. At this point we ran into a nasty short sea, which threw the ship about considerably, and with it the watch below. 8.30 p.m. saw us moving like a train with a fresh beam wind, and, thank heavens, no rain. We were soon threading our way through a scattered Cornish fishing fleet making for home under easy sail; a certain amount of steamer traffic in addition added to the fun and necessitated a sharp look-out. This run from the Longships to Plymouth was sailing for the gods, with a wonderful breeze and a starry sky. 2 a.m. brought the Lizard abeam and a course was set for Plymouth. The wind had moderated by dawn, and we were greatly surprised to see no signs of *Gull* or *Saladin*. We could hardly credit that they had gained so far on us in the night as to be already over the line, as we appeared to have held them fairly well from the Fastnet. It took us some time to grasp the fact that the two white sails astern were our two friends, and how it had happened was as great a mystery to us at the time as it appears to have been to *Gull*. The occasion called for a celebration; Fulmar's health was drunk with all ceremony, although there was some talk about chickens which were not yet hatched.

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As the wind was now moderating considerably it was time to start in on the job of making the ship and ourselves presentable. There was plenty to do! The jack-yarder and jib-topsail were hoisted for the last time, and all ropes ends coiled down. The cabin was then tackled. Everything below was in hopeless confusion, wet blankets, wet clothes and wet sails mingled with all sorts of oddments flung out of the racks on to the floor in the recent turmoil. Luckily the truant sun returned to start in on the job of drying our shore kit. A good meal, the first for some time, and we felt we could face the world again—when we had had a shave. And so 9.30 a.m. saw us burning our flares off Plymouth breakwater, and 9.48 saw us crossing the finishing line under conditions as peaceful as those prevailing when we crossed the line at Ryde, after 6 days 22½ hours continuous racing.

The finishing times were :—

		Corrected.
1st *Jolie Brise*	Fri., 14 hrs. 45 m. 37 sec.	Fri., 14 hrs. 45 m. 37 sec.
2nd *Fulmar*	Sat., 10 hrs. 48 m. 5 sec.	,, 22 hrs. 28 m. 5 sec.
3rd *Gull*	,, 11 hrs. 23 m. 15 sec.	Sat., 2 hrs. 23 m. 15 sec.
Saladin	,, 12 hrs. 54 m. 30 sec.	,, 6 hrs. 54 m. 30 sec.
North Star	,, 24 hrs. approx.	,, 17 hrs. 30 min.

Banba had not finished by midnight Sunday, and *Jessie L.* gave up near the Fastnet and went into Crookhaven under power.

The race was over—bar the shouting, which took the form of a dinner at the Royal Western Yacht Club at which the prizes were presented. *Fulmar's* share was a silver rose bowl which now adorns the headquarters mess. May the larger trophy be there to keep it company in the not too distant future!

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MACAULAY'S SINGLE ELASTIC EQUATION FOR BEAMS.

By CAPT. W. D. WOMERSLEY, Royal Engineers (T), M.A., B.SC., A.M.INST.C.E.

FOREWORD. *By* LIEUT. A. MINNIS, R.E.

THE article which follows has been very kindly contributed by Capt. Womersley in response to a request for a full exposition of Macaulay's method of calculating the deflection of beams.

Capt. Womersley has desired that some explanation be given of its publication in this Journal, as it has already been published in the "Messenger of Mathematics," and in a recently published book on the "Strength of Materials," by Case (reviewed in this Journal).

It has not, however, been presented before in any publication generally read by R.E. Officers, and it will probably be new to most, except those who have gone through the Cambridge Course, and it is thought that it will be of interest as a refresher to them also.

As an illustration of the labour saved by Macaulay's method, (and, consequently, the greater chance of a correct solution), a comparison may be made with the old method in the solution of a simple case such as the first one given by Capt. Womersley.

Referring to Fig. 1 of the article:—

By the old method it is necessary to commence with two differential equations, one for AC and one for CB, introducing four constants on integration.

Thus, for AC

$$-EI\frac{d^2y}{dx^2} = R_A x$$

Integrating

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} + C \quad \ldots\ldots\ldots\ldots \quad (1)$$

Integrating again

$$-EIy = R_A\frac{x^3}{6} + C_1x + C_2 \quad \ldots\ldots\ldots\ldots \quad (2)$$

for CB

$$-EI\frac{d^2y}{dx^2} = R_B x$$

$$-EI\frac{dy}{dx} = R_B\frac{x^2}{2} + C_3 \quad \ldots\ldots\ldots\ldots \quad (3)$$

$$-EIy = R_B\frac{x^3}{6} + C_3x + C_4 \quad \ldots\ldots\ldots\ldots \quad (4)$$

The constants C_2 and C_4 are eliminated from the condition that $y = 0$ when $x = 0$ in both cases $\therefore C_2 = 0$ and $C_4 = 0$.

The constants C_1 and C_3 are found from the condition that y and $\frac{dy}{dx}$ are continuous at C.

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Thus putting $x = a$ in (1) and (2) and $x = (l-a)$ in (3) and (4)

$$R_A \frac{a^2}{2} + C_1 = -\left\{ R_B \frac{(l-a)^2}{2} + C_3 \right\} \quad \ldots\ldots\ldots\ldots (5)$$

$$R_A \frac{a^3}{6} + C_1 a = R_B \frac{(l-a)^3}{6} + C_3 (l-a) \quad \ldots\ldots\ldots\ldots (6)$$

C_1 and C_3 are found by solving the simultaneous equations (5) and (6) and it is in this part of the work that much of the labour occurs.

By Macaulay's method the bending moment equation for the whole beam (referring to Capt. Womersley's article), is equation (7) which, on integration, gives equation (9) for deflection.

As the term within the $\{\ \}$ brackets does not concern the portion AC, it is obvious (from (9)), that when $x = 0$ the second constant is 0.

So that there is only one constant to find, which is easily determined from the condition that $y = 0$ when $x = l$.

In both cases, the constants having been found, the ensuing labour is much the same, but sufficient has been said to show that much labour can be saved by this new method in arriving at this point.

In cases of more complicated loading the saving is proportionately greater; the work up to now is much more easily checked than is possible by the old method, and one can approach the long arithmetical calculation that follows with a greater feeling of security.

In any case, by whatever method it is done, the calculation of deflection in any but the very simplest problems, is a laborious matter; and it is not surprising that the distinguishing feature of such calculations is almost invariably the production of a wrong answer.

To get the right solution, first time, by the old method, needs some luck, as well as great care in avoiding arithmetical errors and such slips in algebra as, say, writing down a + for − sign in one of the many steps; anything that helps to avoid some of this labour, therefore, will also contribute to the chances of arriving at the correct solution.

In some cases it is possible to avoid much of this trouble by use of the "Theorem of Three Moments," but this method breaks down in cases of combined concentrated and distributed loading, owing to the difficulty of finding the areas and centres of gravity of the bending moment diagrams, the boundaries of which are defined by the addition of the ordinates of parabolic and straight line figures.

Macaulay's equation, being of universal application for all systems of loading, supports, or degrees of fixation, provides a short cut through most of the difficulties connected with the determination of deflections and reactions.

THIS very powerful method for determining reactions, deflections, etc., for beams by the use of one omnibus equation was published by W. H. Macaulay, M.A., of King's College, Cambridge, in the "Messenger of Mathematics, Jan. 1919, XLVIII," although it has been in use, through him, in Cambridge for the past two decades or more. The principle may be clearly shewn by considering a simply supported beam with a non-symmetrical concentrated load

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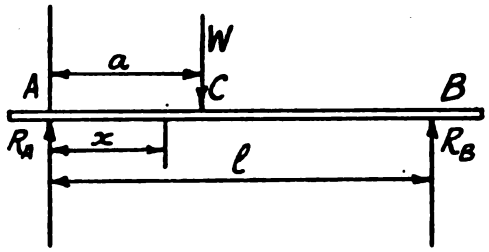

FIG. 1.

as in Fig. 1. Take the end A as the origin and the undeflected centre line AB as the x axis. It is usual to consider the deflection y as positive below AB, that is in the usual negative direction for measuring y, and thus the radius of curvature will be negative and will require a negative sign before being equated to the bending moments producing positive deflections. Thus, from A to C the bending moment equation is :—

$$-EI\frac{d^2y}{dx^2} = R_A.x \qquad (1)$$

which gives the slope equation on integration

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} + \alpha \qquad (2)$$

and the deflection equation on further integration

$$-EIy = R_A\frac{x^3}{6} + \alpha x + \beta \qquad (3)$$

where α and β are constants of integration.
From C to B the bending moment equation is :—

$$-EI\frac{d^2y}{dx^2} = R_A x - W(x-a) \qquad (4)$$

and if this is integrated so that the term $W(x-a)$ keeps its own constant of integration with it, the following equations are obtained for the slope and deflection :—

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} - \frac{W}{2}(x-a)^2 + \alpha_1 \qquad (5)$$

$$-EIy = R_A\frac{x^3}{6} - \frac{W}{6}(x-a)^3 + \alpha_1 x + \beta_1 \qquad (6)$$

Now when $x=a$, (2) and (5) should give the same value for the slope of the beam, and (3) and (6) should give the same value for the deflection, and thus it will be seen that :—

$$\alpha = \alpha_1 \quad \text{and} \quad \beta = \beta_1$$

Hence the equation (4) can be used as the bending moment equation for the whole beam provided that the term $W(x-a)$ is left out when (x) is less than (a), and the integration carried out in the manner shewn in (5) and (6). It is usual to enclose such terms as $W(x-a)$ in special brackets as a reminder of the necessary conditions, as in (7), (8) and (9).

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$$-EI\frac{d^2y}{dx^2} = R_A x - \left\{W(x-a)\right\} \qquad (7)$$

$$-EI\frac{dy}{dx} = R_A\frac{x^2}{2} - \left\{\frac{W}{2}(x-a)^2\right\} + \alpha \qquad (8)$$

$$-EIy = R_A\frac{x^3}{6} - \left\{\frac{W}{6}(x-a)^3\right\} + \alpha x + \beta \qquad (9)$$

The known conditions are, suppose that :—
$y = 0$ when $x = 0$ and l, and thus inserting these conditions in (9)

$$\beta = 0 \text{ and } R_A\frac{l^3}{6} - W\frac{(l-a)^3}{6} + \alpha l + \beta = 0$$

also the bending moment is 0 when $x = l$
$\therefore$ from (7)

$$R_A l - W(l-a) = 0 \quad \text{or} \quad R_A = \frac{W(l-a)}{l}$$

Thus it will be found that :—

$$\alpha = -\frac{Wa(l-a)\ (2l-a)}{6l}$$

and hence the deflection is :—

$$-EIy = \frac{W(l-a)x^3}{6l} - \left\{W\frac{(x-a)^3}{6}\right\} - \frac{Wa(l-a)\ (2l-a)}{6l}\ .\ x$$

This example has been worked out completely since the procedure is exactly the same however many concentrated loads there may be and whatever their sign, and this means, of course, that the method is equally applicable to continuous beams.

(In what follows $\frac{d^2y}{dx^2}$ will be written $\ddot{y}$ and $\frac{dy}{dx}$ as $\dot{y}$) .

The bending moment equation for the beam shewn in Fig. 2 would be :—

$$-EI\ddot{y} = R_A x - [W_1(x-a)] + [R_B(x-\alpha)] - [W_2(x-b)] + [R_C(x-\beta)] - [W_3(x-c)]$$

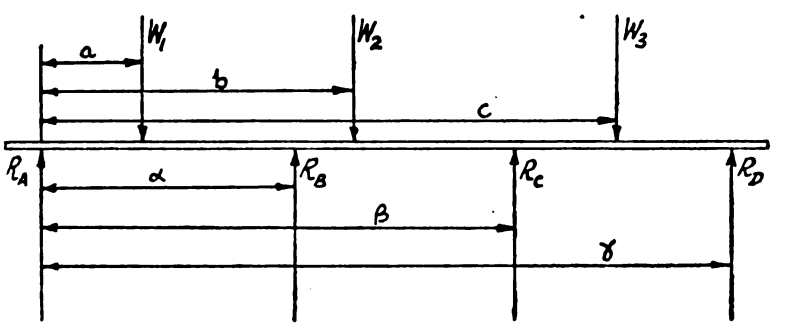

FIG. 2.

Such a case as this would entail considerable labour in its solution and would probably be more easily solved by the use of the Theorem

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of Three Moments, as the areas and positions of the centres of area of the " free " bending moment diagrams are quite easily obtained, but the example has been given to indicate the method of writing down the bending moment equation in a more extended case.

When a uniformly distributed load (*a*) completely covers the beam (*b*) partially covers the beam but extends up to the right hand support, the treatment is exactly the same and offers no special difficulty.

Fig. 3 is an example.

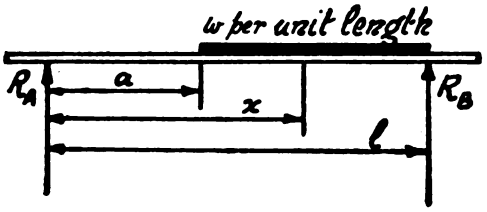

FIG. 3.

The equations are :—

$$-EI\ddot{y} = R_A x - \left\{ \frac{w(x-a)^2}{2} \right\} \qquad (10)$$

$$-EI\dot{y} = R_A \frac{x^2}{2} - \left\{ \frac{w(x-a)^3}{6} \right\} + \alpha$$

$$-EIy = R_A \frac{x^3}{6} - \left\{ \frac{w(x-a)^4}{24} \right\} + \alpha x + \beta$$

If, however, there is an isolated piece of uniformly distributed load, as in Fig. 4, a difficulty arises since the equation (10) would

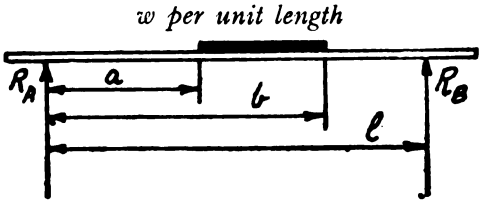

FIG. 4.

not be true for values of (x) between (b) and (l), because ($x-a$) is no longer the length of the distributed load to the left of the section being considered, nor is $\frac{x-a}{2}$ the distance of the centre of gravity of this load to the left of the section and so a special method has to be adopted to overcome the trouble. The distributed load is extended to the right hand support and an extra piece of negative distributed load of the same intensity is introduced under the extended part of the original one as shewn in Fig. 5.

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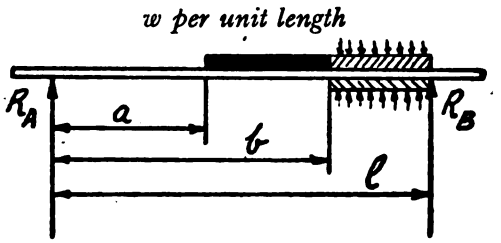

FIG. 5.

It should be obvious that no change has been made statically, as the two extra portions of the loading counteract each other, but the terms which represent the bending moments of the loads are now true to the end of the beam. The solution is as follows :—

$$-EI\ddot{y} = R_A x - \left\{\frac{w(x-a)^2}{2}\right\} + \left\{\frac{w(x-b)^2}{2}\right\}$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - \left\{\frac{w(x-a)^3}{6}\right\} + \left\{\frac{w(x-b)^3}{6}\right\} + \alpha$$

$$-EIy = R_A\frac{x^3}{6} - \left\{\frac{w(x-a)^4}{24}\right\} + \left\{\frac{w(x-b)^4}{24}\right\} + \alpha x + \beta$$

If the conditions are as in the first example, i.e., the deflection zero at the two ends of the beam and the beam simply supported at the ends, then :—

$$\beta = 0;\ \frac{R_A l^3}{6} - \frac{w(l-a)^4}{24} + \frac{w(l-b)^4}{24} + \alpha l = 0$$

and

$$R_A l - \frac{w(l-a)^2}{2} + \frac{w(l-b)^2}{2} = 0$$

whence R_A and α may be determined and the completed equation obtained.

One more special case occurs when an intermediate couple is applied to a beam. Under these circumstances it is a little difficult to co-relate the couple and its distance along the beam with the remainder of the equation. The trouble is most satisfactorily

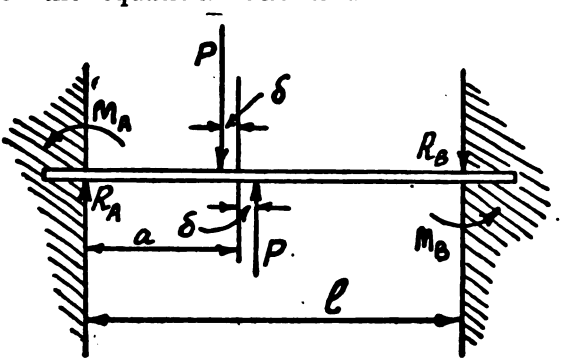

FIG. 6.

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overcome by imagining the couple to be produced by two equal and opposite infinite forces acting an infinitesimally short distance apart and such that the product of the force and distance apart is finite and equal to the couple applied. Consider the case of a beam, say *encastré*, at the ends, and with just the intermediate couple M_C applied at C_1, a distance (a) from the left end. Split the couple up into two infinite forces P a distance 2δ apart as indicated in Fig. 6 and such that $M_C = 2P\delta$. Let the end reactions and fixing moments be as shewn. Then the bending moment equation is as follows :—

$$-EI\ddot{y} = R_A x - M_A - [P(x-a+\delta)] + [P(x-a-\delta)]$$

whence

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - \left\{\frac{P}{2}(x-a+\delta)^2\right\} + \left\{\frac{P}{2}(x-a-\delta)^2\right\} + \alpha$$

Since the beam is *encastré* at both ends then :—

$$\dot{y} = 0 \quad \text{when} \quad x = 0 \text{ and } l$$

whence

$$\alpha = 0$$

$$R_A \frac{l^2}{2} - M_A l - \frac{P}{2}\left((l-a) + \delta\right)^2 + \frac{P}{2}\left((l-a) - \delta\right)^2 = 0$$

and from this

$$2M_A l - R_A l^2 = -4P\delta(l-a) = -2M_C(l-a) \qquad (11)$$

Integrating again

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} - \left\{\frac{P}{6}(x-a+\delta)^3\right\} + \left\{\frac{P}{6}(x-a-\delta)^3\right\} + \beta$$

Again

$$y = 0 \qquad \text{when } x = 0 \text{ and } l$$

and therefore

$$\beta = 0$$

$$R_A \frac{l^3}{6} - M_A \frac{l^2}{2} - \frac{P}{6}\left((l-a) + \delta\right)^3 + \frac{P}{6}\left((l-a) - \delta\right)^3 = 0$$

whence

$$3M_A l^2 - R_A l^3 = -6P\delta(l-a)^2 - 2P\delta.\ \delta^2$$
$$= -3M_C(l-a)^2 \qquad (12)$$

since δ^2 is an infinitesimal of the second order.
From (11) and (12) it will be found that :—

$$R_A = \frac{6a(l-a)}{l^3} M_C \text{ and } M_A = \frac{(l-a)(3a-l)}{l^2} M_C$$

and the complete equation is :—

$$-EIy = M_C \frac{a(l-a)}{l^3} x^3 + M_C \frac{(l-a)(l-3a)}{2l^2} x^2 - \left\{M_C \frac{(x-a)^2}{2}\right\}$$

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A few numerical examples follow indicating the types of problem that may be encountered and shewing the universal applicability of the method.

Example I.

A uniform girder is continuous over two spans of 30 feet and 40 feet respectively, and carries a uniformly distributed load of 2 tons per foot run extending for 20 feet on each side of the intermediate support, which sinks 0.1 inch per ton load on it, the end supports being rigid. The " Moment of Inertia " of the girder section is $\frac{1}{8}$ in foot-units and Young's Modulus of Elasticity for the material is 4,000 tons per square inch.

The beam ready for operation is shewn in Fig. 7.

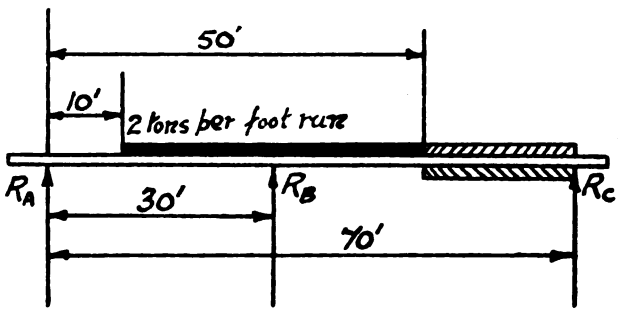

FIG. 7.

The equations are :—

$$EI\ddot{y} = R_A x - \{(x-10)^2\} + \{R_B(x-30)\} + \{(x-50)^2\}$$

$$EI\dot{y} = R_A\frac{x^2}{2} - \left\{\frac{(x-10)^3}{3}\right\} + \left\{\frac{R_B(x-30)^2}{2}\right\} + \left\{\frac{(x-50)^3}{3}\right\} + \alpha$$

$$EIy = R_A\frac{x^3}{6} - \left\{\frac{(x-10)^4}{12}\right\} + \left\{\frac{R_B(x-30)^3}{6}\right\} + \left\{\frac{(x-50)^4}{12}\right\} + \alpha x + \beta$$

The known conditions are that :—

$x = 0$ when $y = 0$ (1)

$x = 30$ ft. $y = \frac{0.1}{12} R_B$ feet (2)

$x = 70$ ft. $\begin{cases} y = 0 & (3) \\ \ddot{y} = 0 & (4) \end{cases}$

Thus from (1) $B = 0$

from (2) $A = \frac{4000}{9} - 150R_A - \frac{280}{3}.R_B$ (5)

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from (3) and (5) $350R_A + 31R_B = \frac{23,300}{3}$ (6)

from (4) $54.25R_A + 31R_B = \frac{7440}{3}$ (7)

Thus from (6) and (7) R_A=17.9 tons, R_B=48.7 tons, R_C=13.. tons and any other quantities desired may then be found.

Example II.

A beam 40 feet long is *encastré* at both ends and carries a load o 10 tons at a point 10 feet from one end and 10 tons uniformly distributed over the other half of the beam. To determine th reactions and the fixing moments, etc.

(Technical Examination for R.E. Officers, December, 1925).

The beam should be arranged as in Fig. 8.

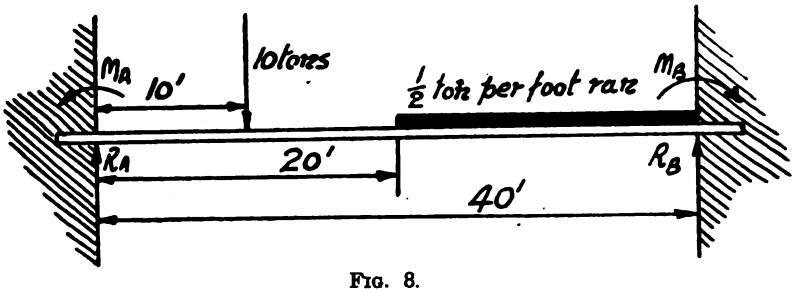

FIG. 8.

$$-EI\ddot{y} = R_A x - M_A - \{10(x-10)\} - \left\{\frac{(x-20)^2}{4}\right\}$$

$$-EI\dot{y} = R_A\frac{x^2}{2} - M_A x - \{5(x-10)^2\} - \left\{\frac{(x-20)^3}{12}\right\} + \alpha$$

now $\alpha = 0$ since $\dot{y} = 0$ when $x = 0$

$$-EIy = R_A\frac{x^3}{6} - M_A\frac{x^2}{2} - \left\{\frac{5}{3}(x-10)^3\right\} - \left\{\frac{(x-20)^4}{48}\right\} + \beta$$

also $\beta = 0$ since $y = 0$ when $x = 0$

when $x = 40$ feet $y = 0$ and $y = 0$

whence $60R_A - 3M_A = 387.5$

and $40R_A - 3M_A = 181.25$

from which

$R_A = 10.3125$ tons and $M_A = 77.08$ foot-tons.

The remainder follows at once.

Example III.

A vertical stanchion is *encastré* at the lower end and supported horizontally at the upper end. The length of the stanchion i 10 feet, and 8 feet from the ground level, a crane runway bracket i rigidly attached to the stanchion and may carry a load of 5 tons a

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a distance of 2 feet from the axis of the stanchion. Effect of direct compression is neglected.

The stanchion and its arrangement for solution are shewn in Fig. 9.

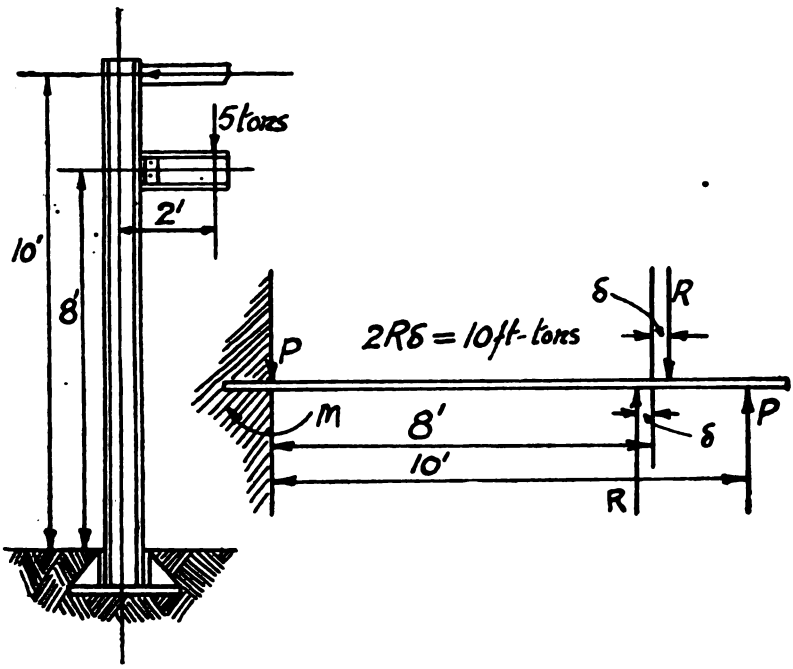

FIG. 9.

$$-EI\ddot{y} = M - Px + [R(x-8+\delta)] - [R(x-8-\delta)]$$

$$-EI\dot{y} = Mx - P\frac{x^2}{2} + \left\{\frac{R}{2}(x-8+\delta)^2\right\} - \left\{\frac{R}{2}(x-8-\delta)^2\right\} + \alpha$$

Now $\alpha = 0$ since $\dot{y} = 0$ when $x = 0$

$$-EIy = \frac{Mx^2}{2} - \frac{Px^3}{6} + \left\{\frac{R}{6}(x-8+\delta)^3\right\} - \left\{\frac{R}{6}(x-8-\delta)^3\right\} + \beta$$

also $\beta = 0$ since $y = 0$ when $x = 0$

Now $\ddot{y} = 0$ when $x = 10$ feet.

Therefore $10P - M = 10$

also $y = 0$ when $x = 10$ feet

whence $50P - 15M = 3$

and thus $M = 4.7$ foot tons and $P = 1.47$ tons.

Any other quantities can now easily be determined.

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SYNCHRONOUS ELECTRIC CLOCKS, WITH PARTICULAR REFERENCE TO THE SYSTEM AT THE S.M.E.

By CAPTAIN C. C. S. WHITE, M.B.E., R.E.

Electrically operated clocks are apt to be regarded as a luxury, whereas, in point of fact, in many cases, they are an economy, and can effect an appreciable saving on the system of paying so much a year for "clock winding." In addition to this there is the inestimable advantage that all clocks are in absolute and perfect synchronism with the master clock and with each other.

Before deciding to instal a system of electric clocks there are two main items which require careful consideration :—

(1) The distance between clocks ;
(2) Personnel for maintenance.

In theory there is no limit to the distance over which clocks can be operated, but in practice it becomes a question of whether the capital expenditure on line construction is justifiable. The most favourable conditions for their use are either a concentrated area, or where telephone or overhead power lines are already existing, and an extra pair of wires can be run for a very slight extra cost.

With regard to the personnel required for maintenance, no very great electrical knowledge is required, and the work can easily be done by an electric power lineman or a telegraph lineman and an instrument maker or electrician. Electric clocks are not delicate, scientific instruments, needing expert manipulation and attention, but strong, sturdy, substantial and reliable articles ; nevertheless it is desirable, except with the smaller sizes of impulse clock, to instal them in a situation which is not liable to jarring or severe shaking. Incidentally the clocks are usually sealed by the makers, and seldom require attention.

Two of the main advantages, absolute uniformity and no winding, have already been mentioned. Other advantages are that the original outlay is no greater than that of installing an equivalent number of clocks in a small area. Extra clocks can be easily added at a small cost. All that is necessary is to run two wires from the nearest point on the existing circuit to the new clock, and add one or two cells to the battery.

The system can be extended to include turret clocks, striking clocks and sound signals, to operate automatically according to any desired programme.

The main disadvantage is that if a break occurs in the circuit all clocks stop, since the clocks are usually connected in series but even this can be considered preferable to having numerous

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clocks out of synchronism. Of course, a short-circuit on the line will prevent those clocks on the loop getting the impulse, and they will consequently drop behind, but such a fault will be of rare occurrence with a well constructed line.

Various Systems.

There are various systems of electrically operated clocks, but the principles are very much the same in each case. The general idea is to have a Master Clock, whose function is two-fold; firstly, to keep accurate time, and secondly, to control the other clocks, usually by half-minute or minute impulses.

The master clock can be sustained either electrically or mechanically. In the "Synchronome" and "Pulsynetic" systems the movement of the pendulum is sustained every half-minute by the fall of a "Gravity Arm," re-setting being effected by an electro-magnet operated by the main battery. The magnitude of this impulse depends upon gravity, a constant force for all practical purposes. Direct impulsing by an electro-magnet is not advisable, as the magnitude of the impulse will vary with the strength of the battery, so electro-magnetic sustaining cannot give constant time keeping, except, possibly, under special laboratory conditions.

"Princeps" System.—The "Princeps" electric clock is maintained by an ingenious method; the pendulum receives a small additional impulse from a side contact spring every complete vibration, this spring being returned to its normal position by a movable stop, controlled electrically.

"Magneta" System.—In the "Magneta" system, the master clock is not operated electrically. A release arm is actuated by a pin wheel, and the energy generated by the falling weight operates a magneto, which drives the secondary clocks, and at the same time re-winds a small remontoir spring which maintains the pendulum.

The Pulsynetic System.

Master Clock.—The action of the Transmitter or Master Clock is exceedingly simple. Normally, while swinging with the pendulum, the pallet P of the crutch H passes close under, but does not (and must not) touch the roller R, which is pivotally mounted on the gravity or impulse lever G.

The driving pawl D pushes round the escape or time wheel E, tooth by tooth, with each oscillation of the pendulum. The pawl B prevents the backward rotation of this wheel. At each half-minute, however (one revolution of the wheel), the driving pawl D enters the deep cut tooth E_1, and the extension on D_1 of the pawl D rises, and engages the supporting or stirrup catch at the point S_1, instead of passing freely through the loop as normally. The supporting catch S is then pushed out of engagement with

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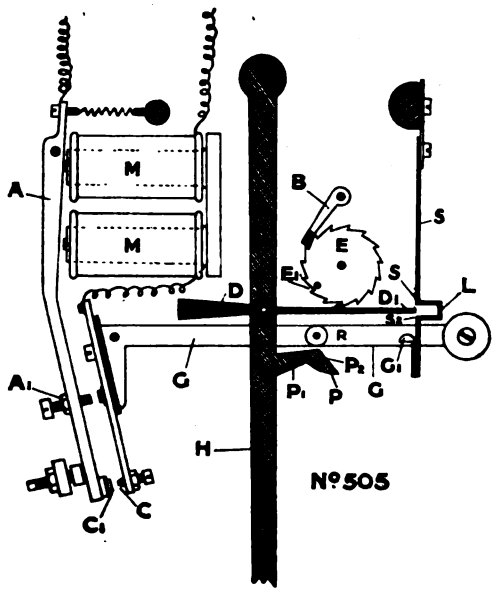

FIG. 1.

the gravity lever G at G1, allowing the gravity lever to fall. The roller R of the gravity lever drops on to the inclined plane P2 during the pendulum's swing to the left, thus imparting to it, mechanically, a gravity impulse of unvarying force. The downward path of the gravity lever is definitely arrested at a pre-determined point by the contact C meeting the contact C1. The circuit being then completed through the electro-magnet MM and the external circuit, which is composed of the battery and impulse clocks arranged as in Plate No. 2, the armature A is attracted, and so throws the gravity lever to its normal position. Whereupon the contact is broken by the breaking screw A1 ; this arrests the motion of the armature and causes the contacts C and C1 to separate. This contact is self-adjusting in relation to its duration, because the action takes place quicker while the current flowing through the circuit is strong, but when the battery weakens, the duration is prolonged by the action of replacement taking place more slowly, thereby increasing the duration of the contact, and so giving all clocks in the circuit time to operate with the weaker current.

If for any reason it is desired to advance all the clocks on the system, this can be done by holding down the "repeating cord," and so depressing the pawl D1, which will then engage with the supporting catch S at S2 at each vibration of the pendulum, thus releasing the gravity lever G and causing it to make contact every two seconds instead of every half-minute.

In order to retard the clocks, the pendulum may be stopped for so long as is necessary.

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It is interesting to note that, in order for the transmitter to work correctly, the gravity lever must be lifted to its correct position by the current the instant the contacts C and C1 meet. If the gravity lever remains down until it is assisted back by the pendulum, then the duration of the impulse is one second instead of 1/30th, and the warning bell will ring.

Warning Bell.—A warning bell is incorporated in the impulse circuit to indicate when the battery current becomes too weak to work the clocks satisfactorily. It is a single stroke trembler bell with its hammer loosely adjusted, so that it has not time to hit the gong when the duration of an impulse is normal, *i.e.*, 1/30th sec. But when the battery current drops below 0.17 ampere, and the resetting of the gravity lever (G) is not so rapid, the duration of the impulse is increased; then the hammer has time to hit the gong and so give audible warning that the battery requires attention.

Battery.—The battery can well be either dry or wet Leclanché cells. The load is ideal for this type, being 0.18 ampere for a very short impulse, somewhere in the neighbourhood of 1/30th of a second, and occurring every half-minute. The battery should last for a year or more without requiring attention, and have a useful life of three or four years at least.

Impulse Clocks.—Clocks with dials up to 3ft. 6 inches diameter are usually directly operated by means of a simple electro-magnetic, and are known as impulse clocks. The power taken by these clocks depends upon the size of electro-magnet required—the larger the clock the greater the ohmic resistance, and so the greater the voltage drop and the power consumed in that part of the circuit. Incidentally, the total yearly consumption of energy for all clocks on the S.M.E. circuit is .064 of a unit.

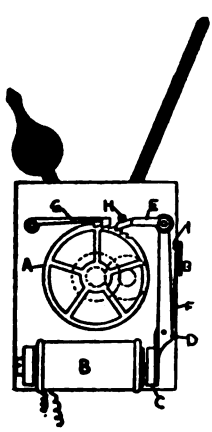

FIG. 2.

Waiting Train Clocks.—Larger clocks, such as turret clocks, and in fact all clocks whose hands are exposed to the weather, are best operated by a "Waiting Train" movement.

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Briefly, this is an independent clock, electrically operated by its own battery, but its hands are arranged so as to move through a half-minute space in from 27 to 28 seconds, and then wait for a release caused by an impulse from the master clock.

The "mainspring" of a waiting train movement is an electrically driven heavy pendulum, the function of which is not to keep time, but to drive the hands of the clock. The motor pendulum is energised by an electro-magnet when its oscillations fall below a certain pre-determined arc. Under normal working conditions re-energisation takes place about once per minute, but when heavy work is being thrown on the hands, the motor pendulum becomes energised more frequently—as often as every complete vibration if necessary. On being energised at each vibration, the pendulum develops 30 times its normal power, and it is impossible to stop the movement by hand, even when exerting one's full power on the worm wheel.

The dis-association of the driving mechanism from the time-keeping ensures that the accuracy of a turret clock is determined by the master clock, and an accuracy of one second per week is easily obtainable.

Another feature of electric operation is the entire absence of heavy clock weights, with their attendant troubles due to suspension, possibility of falling, etc. The motive power is provided by a local battery, which can be housed wherever convenient.

The half-minute control is arranged as follows:—The gear ratio of the turret clock is such that the minute hand is driven through a half-minute space on the dial in from 27 to 28 seconds. The pawl of the motor pendulum is then automatically lifted out of engagement with the ratchet wheel, so that, although the motor pendulum maintains its action, the hands remain stationary for two or three seconds, locked by the worm gear. A current impulse from the transmitter, dead on the half-minute, releases the pawl, and the hands are driven forward for another half-minute on the dial. As a rest of two or three seconds is inappreciable, the hands appear to move with regular progression, and not in half-minute jumps as in the case of impulse movements.

A waiting train movement is recommended for all exterior clocks when the diameter of the dial exceeds 3ft. 6 inches.

Striking or Chiming Clocks.—Clocks can be arranged to strike or chime electrically. In the case of large clocks this is usually done by means of motor-driven gear arranged as in Diagram No. 3, or by a "Waiting Train" movement. The drop hammer, motor-driven method will strike church bells of two tons weight. Chimes for small clocks can be operated direct off the impulse circuit by means of a special instrument.

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PLATE 1.

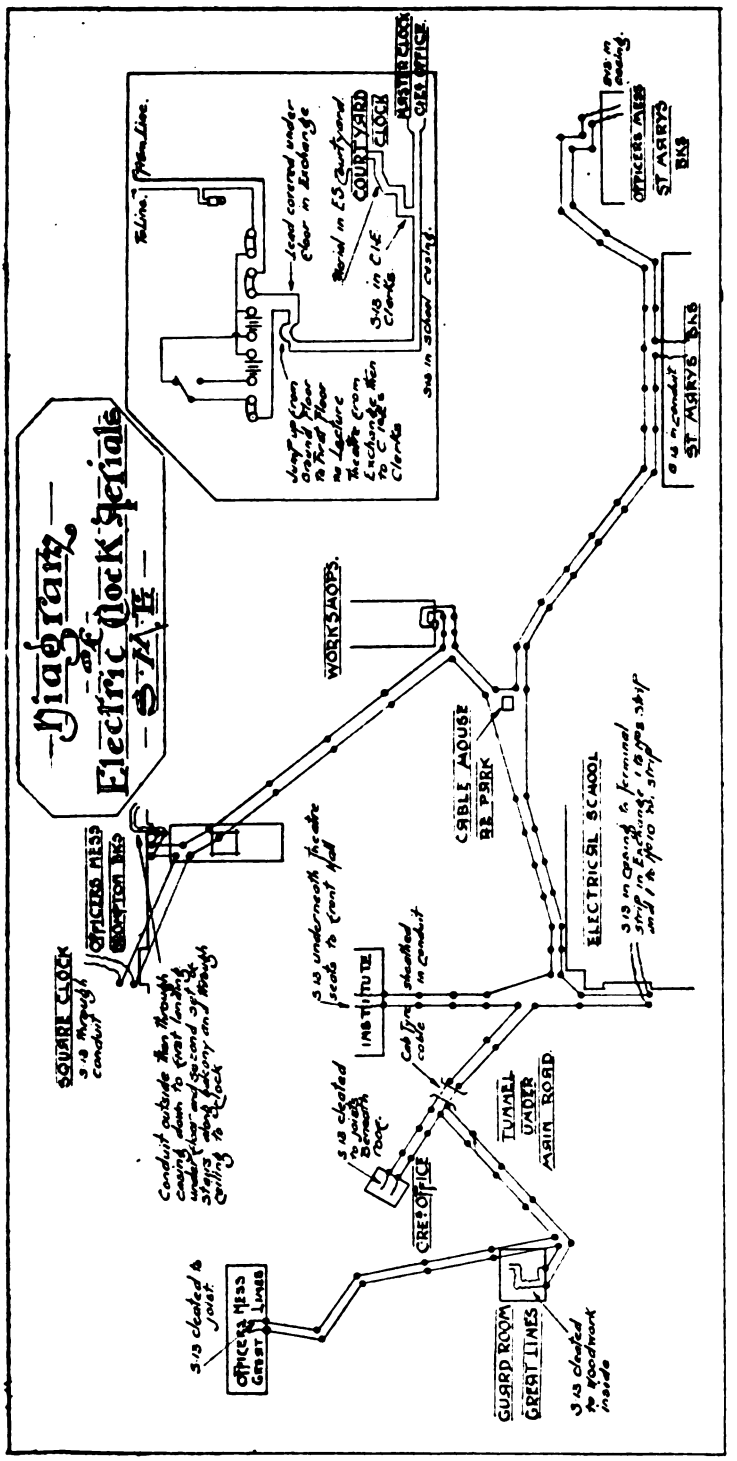
Diagram of Electric Clock Aerials
Site
Telephone
Lead covered under floor in Exchange
Aerial in Courtyard
COURTYARD CLOCK
ASTRO CLOCK OBS OFFICE
3/8 in steel cable.
3/8 in Clock Cable
Lead in Exchange to Clocks
3/8 in Clock Cable
Lead from Ground floor to First floor to Lecture Theatre from Exchange to Clocks
3/8 in Clock Cable
SQUARE CLOCK
3/8 in Metal conduit
OFFICERS MESS
GUNNERS MESS
Conduit outside then through casing down to first landing under floor and second floor stairs along balcony and through ceiling to Clock
WORKSHOPS.
3/8 in underneath footpath leads to front hall
CABLE HOUSE
RE PARK
ELECTRICAL SCHOOL
3/8 in Cable to terminal strip in Exchange 16 pair Lead and 16 pair to Lt. strip
INSTITUTE
Cable from cable sheathed in conduit
3/8 in sheathed to roof Between roof
CRE1 OFFICE
TUNNEL UNDER MAIN ROAD
OFFICERS MESS GUNNERS LINES
3/8 in sheathed & joist
GUARD ROOM GREAT LINES
3/8 in sheathed to Woodwork inside
3/8 in Cable
ST MARYS BKS
OFFICERS MESS
ST MARYS BKS

DIAGRAM 1.

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INSTALLATION AT THE S.M.E.

In August, 1921, it was decided to instal "Pulsynetic" electric clocks at the S.M.E. The scheme adopted was to replace the existing mechanical movements by electrical control in the three main clocks at Brompton Square, St. Mary's Barracks and S.M.E. Workshops. Brompton Square clock was considered too large a clock to be operated directly off the impulse circuit, for which reason a "Waiting Train Movement," with its own independent battery, was ordered. Eight small impulse clocks were installed in the entrance of the S.M.E. Main Building, the Electrical School Courtyard, the three Officers' Messes, Great Lines Guardroom and in the C.R.E's. Office.

A master clock to control all the above was installed in the C.R.E's. office, and a battery in the S.M.E. Telephone Exchange.

An order for the necessary apparatus was placed with Messrs. Gent and Co., in September, but, owing to delays in getting the line stores, it was not until March, 1922, that the main portion of the installation was completed.

The total cost of the whole installation, omitting labour costs, was £189 12s. 9d., made up as follows:—

	£	s.	d.
Brompton Barracks Square.			
Supplying and fitting "Waiting Train" movement clock, 3' 6" dial.	36	10	0
St. Mary's Square.			
Supplying and fitting Impulse clock, 2' 6" dial. ..	7	6	0
S.M.E. Workshops.			
Supplying and fitting Impulse clock, 3' 0" dial. ..	6	18	0
Electrical School Courtyard.			
Impulse clock, 12" dial.	5	0	0
Seven Impulse clocks for interior use, at £3 15s. 6d. each, 9" dial.	26	8	6
Master clock	17	8	9
Warning bell	2	5	0
3½ miles hard drawn copper wire, 1/16—light insulation	23	4	9
Wire, electric, S.13	3	13	4
Wire, electric C.T.S. twin	6	10	0
Insulators, bolts and line stores..	48	6	1
Cells, electric, Leclanché	5	2	0
Sal ammoniac	1	0	4
Total	£189	12	9

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It will be seen that a very large proportion, nearly half, of the expenditure is on the line. The total length of wire in circuit is just over 3½ miles.

Brompton Square clock, which has a "Waiting Train" movement, has proved to be most satisfactory. It has stopped only once—in August, 1923—when 4 cells of the local battery were discovered completely dry. This battery is on the roof of the Brigade Major's quarters—a very hot situation when the weather is at all warm.

The two large exterior clocks in St. Mary's Barracks and S.M.E. Workshops, fitted with impulse movements, have not proved to be quite so satisfactory. They are apt to be affected by the wind and weather.

The most satisfactory type of exterior clock, other than the "Waiting Train," is the impulse movement in water-tight cast iron case in the Electrical School Courtyard, which has given no trouble whatsoever, but the dial is too small for a Square clock.

All the interior impulse clocks are in plain air-tight wood cases, and have required no attention.

In order to ensure the aerial line being as safe as possible, it was considered advisable to use insulated hard drawn copper wire, No. 16 S.W.G., and to have the clock wires as cap wires on "cow-horn" insulators on the telephone poles.

Duplicate batteries are installed at the S.M.E. Telephone Exchange to admit of one being rested and refreshed whilst the other is in use. This is really rather more of a luxury than a necessity, as the load on the battery is so small that half-a-dozen spare cells is all that is required for "stand-by" and cleaning purposes.

To calculate the size of the battery required, allow a working current of 0.17 to 0.25 ampere for the impulse circuit. The current must not fall below 0.17 ampere, and should not exceed 0.25 ampere. The battery at the S.M.E. is composed of 28 Leclanché cells, and the total resistance of the circuit is 167 ohms, made up as follows :—

	ohms.
Brompton Barracks relay	16
Workshops clock	18
St. Mary's Square clock	40
8 Impulse clocks at 3 ohms each	24
Master Clock	25
Warning bell	4
Line resistance	40
Total	167

From the date of installation up to June, 1925 (over 4 years), there have been six occasions of complete breakdown; four of these were caused by breaks in the line wires (two occurring in the abnor-

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mally high gales experienced throughout the country in December, 1924), and the other two by accidents to portions of the indoor wiring. In addition to the foregoing, a mysterious fault which causes all clocks, except that at Brompton Square with the " waiting train " movement, suddenly to gain from 5 to 10 minutes, has occurred during the winter months each year, and always at night. It is obvious from the results that the master clock must have been giving additional impulses, for such interim impulses would necessarily be ignored by the " waiting train " movement, but the cause has not yet been discovered. The logical conclusion is the presence of an intermittent line fault of moderately high resistance which appears only during the colder hours, causing the line current to fall sufficiently to prevent the re-setting of the gravity arm of the Master Clock, although not enough to affect the action of the impulse clocks.

Too much attention cannot be paid to the careful planning and selection of the aerial route, and when insulated wire is used, particular care should be taken to avoid long spans and exposed positions, as both the weight of the wire and the wind pressure are increased very considerably more than the mechanical strength of the wire.

As regards time keeping, the accuracy of the master clock is all that can be desired for all practical purposes. The regulation of the master clock is an extremely simple matter. It is done by adding or subtracting small weights to the pendulum, or by giving a fraction of a turn to the main bob. Temperature appears to make no material difference, as the pendulum is compensated, and it is easy to ensure that the error shall not exceed a second a day.

The author wishes to thank Messrs. Gent and Co. for their kindness in permitting the publication of the diagrams and for the use of their blocks.

Note.—Since this article was written the clocks from the Great Lines Hutments have been moved to the Lower Barracks, Chatham. The aerial line from the C.R.E.'s Office to the Lower Barracks is 40-lb. bronze wire on the telephone poles, and has given no trouble.

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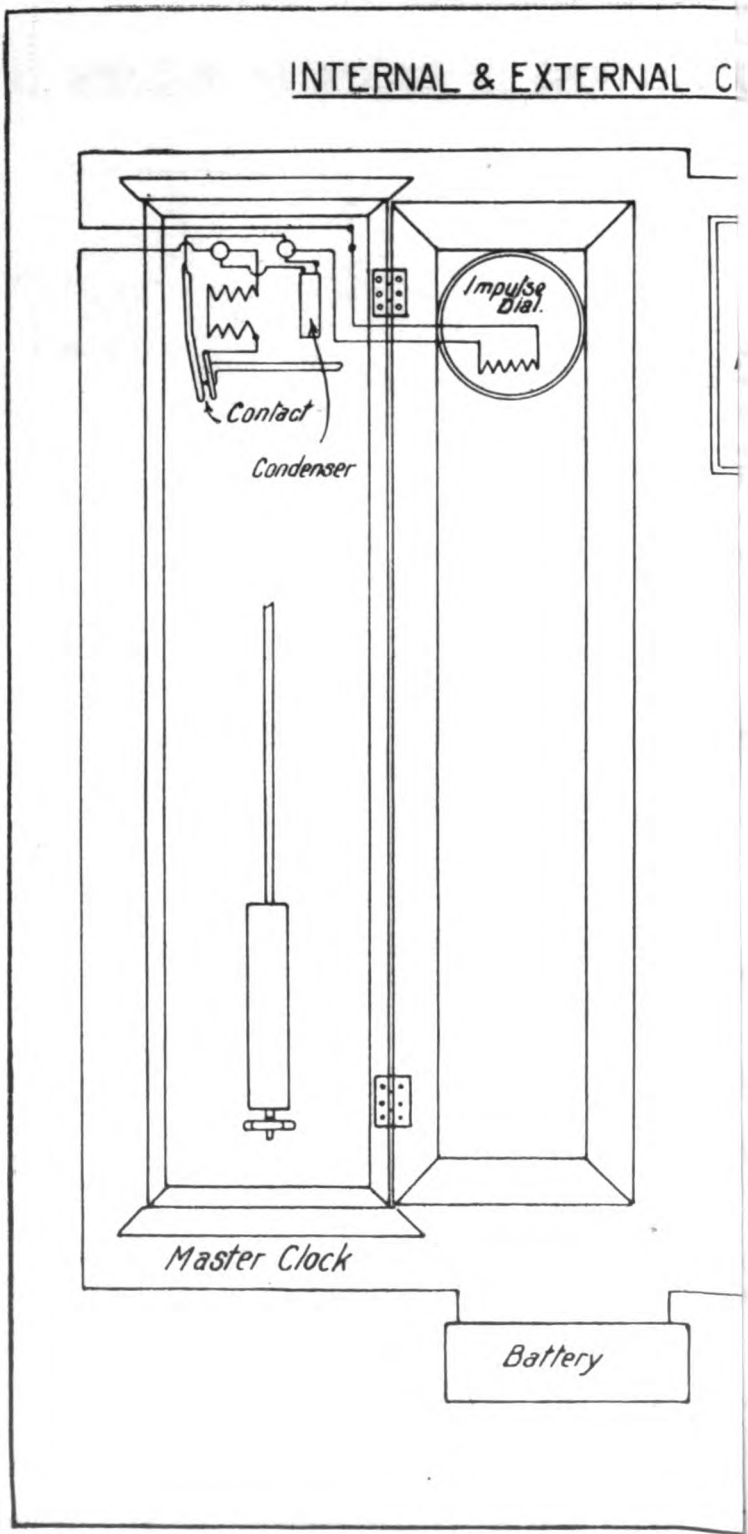

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TANK OBSTACLES.

By CAPTAIN H. P. W. HUTSON, D.S.O., O.B.E., M.C., R.E.

The Tank a real menace.—The tank and its possibilities constitute a very serious problem for the defence. There is real danger that a superior tank attack will over-run the position, and once the tanks have penetrated amongst the Infantry their effect is locally decisive. How is the menace to be met ?

Existing anti-tank weapons inadequate.—The means at present available for engaging hostile tanks are :—(*a*) One's own tanks. (*b*) Artillery Fire. (*c*) Aeroplanes.

Probably the tank itself forms the best weapon, but in view of the limited number it is more than doubtful if sufficient could be spared for the purpose. Certainly, in the opening stages of a campaign, the bulk would have to be retained in reserve for use at the decisive point.

This same difficulty—inadequacy of numbers—arises when the employment of artillery for anti-tank work is considered. Even if we take the field with batteries organised on a six-gun basis, the general opinion is that the army would be under-gunned. To tie up field guns in silent positions, such as successful anti-tank defence demands, would diminish still further the numbers available for their chief function of dealing with the opposing infantry and artillery. Moreover, the question of providing a suitable weapon for anti-tank work is still to be solved. The 3.7 inch howitzer was designed to meet the combined requirements of close support and anti-tank defence. Like most attempts at a compromise the result has failed to give entire satisfaction in either rôle.

We know little about the possibilities of air attack against tanks. It may be assumed, however, that such employment would necessitate low flying and a consequent high proportion of casualties to the aircraft. The normal allotment of army co-operation machines would probably be three squadrons to a Corps of three Divisions. This is not a large number when the reconnaissance and artillery observation duties required are considered. Consequently, any extensive use of this arm for anti-tank defence may be regarded as improbable.

Increase in anti-tank weapons unlikely.—The present urgent necessity for economy throughout all Services and Departments renders any material increase of our anti-tank armament unlikely in the near future. It is true that the Infantry are asking for an anti-tank weapon for themselves. But, apart from the question of

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expense, it would seem unwise to add further to the battalion's load. It already has as much as it can cope with efficiently and any additional weapon would hamper it and lessen its mobility. Further, it must not be forgotten that tank design is still in the embryonic stage. Hence, changes are likely to be both rapid and far reaching. There is no guarantee that a weapon of the heavy machine gun type, capable of piercing the armour of the present light tank, would be able to engage future models, which we may expect to see more heavily armoured and proof against any weapon manned by infantry personnel. As things are at present, we must recognise that the armament of the army is insufficient by itself to ensure adequate protection against tanks along the whole of a normal front.

Essential to restrict tank approaches.—If, then, the defence is to be able to beat off a tank attack, the approaches open to the enemy tanks must be so restricted that the defenders' weapons can cope with the situation. The cross-country powers of the tank are by no means unlimited. With improved design, increased ability to negotiate obstacles may be expected, but for some time to come there will be many features, natural and artificial, which it can either not cross at all or at which its speed is so decreased that the weapons of the defence will have time to engage it effectively. The problem for the defenders is to so select their positions that they include areas unsuitable for enemy tank movement, and, where such areas are inadequate, to supplement them by artificial means.

Natural obstacles often available.—There will be few theatres of war from which natural tank obstacles will be absent altogether. In most parts of Europe such features are numerous. Woods, rivers, swamps and villages are common objects of the country side, and will usually be impassable for tanks except by defined passages. Elsewhere steep-sided ravines, boulder strewn *nalas* or rocky outcrops may provide what is wanted. Mountainous districts will always limit the tank's possibilities.

Of course, it will be impossible to confine operations to such localities as these, but they occur generally throughout the world and wherever feasible should be utilised to narrow down the possible approaches to a position.

Artificial obstacles required to supplement.—It will seldom be the case, however, that the natural obstacles are sufficient by themselves. Whilst one flank of a position may be in close country passable by tanks along a limited number of tracks only, the other may be in open down land traversable anywhere. Obviously the exposed portion of the line requires some form of artificial obstacle. To what extent and in what form can this be provided?

In permanent defences cost is usually the chief concern, and questions of time, labour and materials are of secondary importance.

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Mechanical equipment, too, will be available, permitting extensive excavation and massive construction. Consequently large and elaborate obstacles are possible.

But in mobile warfare conditions are very different. Time will nearly always be the deciding factor, and the supply of labour and tools will be strictly limited. There can be no question of steel or concrete structures. The obstacles will have to be made with such materials as exist on the site or can be brought there with a minimum of transport. Practically, therefore, field obstacles are limited to two types :—(i) earthworks ; (ii) mines.

Earthworks usually impracticable.—Earthworks possess the great advantage that no materials are required for their construction. But their drawbacks and limitations are obvious and were well illustrated at some recent tests. A series of ditches, trenches and craters (see Plate A) were prepared and heavy and light tanks were driven over them. The designs embodied the latest views on this form of tank obstacle, but their efficacy as such can only be described as disappointing. Not one presented the slightest difficulty to heavy tanks of the type used at the end of the Great War. With the exception of the Grid and the Shelled Area they did, however, constitute a serious hold-up for the light tank, and the tests shewed that the Four Foot Ditch is an obstacle which may be relied upon to stop this type of tank. But the light Tank is by no means the final word in tank design. In many respects it is only a glorified armoured car, and future developments will certainly lead to the production of a model with greater power of surmounting obstacles.

Yet though this was the only type of tank which the earthworks under test were capable of stopping, the labour involved in the construction of even the four-foot ditch would make its general employment impossible. It was found that from 190 to 330 man-hours were required to dig a hundred yards of this ditch, according as the soil was sand or gravel. Now, take the case of a brigade group which has been given a 3,000-yard sector of a position and told that it has four hours in which to complete all defensive arrangements. What men are likely to be available for digging tank ditches? Probably none, but for the purposes of illustration we will assume that a working party of 500 is found from the battalion in reserve. Such a party could, in the four hours available and under the most favourable conditions of soil, dig 1,000 yards of ditch, but for average soils 600 yards would be a fair figure. At first sight this does not seem an inconsiderable length for a 3,000 yard front, but the assumptions upon which it is based are not likely to be realized in war. The 500-strong working party would in all probability be about half that number, and in addition the men would almost certainly be tired. If we take 200 yards as the maximum length of this type of

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tank obstacle which a brigade group will be able to construct on its front, we shall be nearer the mark for conditions of moving warfare. Consequently, even when the enemy is equipped only with light tanks, the time and labour necessary adequately to protect the front with tank ditches is so prohibitive that this form of obstacle will seldom be feasible during mobile operations. When positions are prepared some time in advance, the time and labour factors will be of less importance and the construction of these obstacles may be possible. But the difficulty of concealing them, both during and after construction, must militate greatly against their efficiency. It will never be practicable to cover the whole front with a continuous obstacle, and if the attacker knows beforehand what portions have been protected he can make his preparations accordingly. We may conclude, therefore, that whilst on occasions earthworks may be usefully employed, they do not provide a tank obstacle capable of general employment in the field.

Mines offer a better solution.—What is the situation as regards mines? The *Manual of Field Works* (*All Arms*) states that mine-laying is a dangerous operation and should be carried out by experts; also that careful records should be kept of the positions of all mines laid. If this is to apply to the tank mine its usefulness will be severely limited. The essential factor of a good tank obstacle is suitability for rapid construction or placing. Laying by experts and careful records do not make for speed. What is required is a small portable mine, weighing about ten pounds, and possessing a simple safety device secure against rough handling. Only a shovel should be needed for placing it, and once laid the mine should be so selective that the weight of a man will not set it off. These considerations should not be impossible of fulfilment. The mine would achieve its purpose if it destroyed the tracks of the tank and so rendered it immobile. A comparatively small charge should ensure this. Safety could be obtained by some form of pin to be withdrawn after the mine is in position. It is only as regards its selectivity that there is likely to be much difficulty. Possibly we shall have to be content if safety against discharge by a man's weight is provided for and risk the possibility of horses or transport firing it. If, then, a mine of this type is produced, and there is no apparent reason why this should not be done, it will certainly form the best, and probably the only really satisfactory, form of tank obstacle.

The labour in laying will be small. So will the time, and eventually this may be quickened still more by some device by which the mines are laid by cross-country vehicles. Moreover, the minefield will be inconspicuous, and thus constitute a menace which the attackers cannot foresee, and therefore cannot avoid except by chance.

Should be carried by Divisional R.E.—Assuming, therefore, that a suitable mine can be designed and will be adopted as the standard

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tank obstacle, the question arises as to who is to carry the mines. Though these are not for handling by experts only and can be laid by any troops, it is desirable that " mines " should be the responsibility of one arm. Then the normal procedure would be for this arm to lay the mines, but where necessary to issue to other arms to lay themselves. Such an arrangement would ensure a more economical use of the mines than if they were distributed generally, and would tend to more rapid progress in the methods of mine construction and laying.

The infantry are already overburdened. It would be unwise to hamper them still further. Either the tanks themselves or the Divisional R.E. could better undertake the work. The tank battalions are Corps troops and a division may or may not have tanks allotted to it, but it will certainly ask for mines. If these were carried by the tank battalions it would mean the detachment of their mine carriers throughout the Corps, which is not desirable. Further, it might be essential to lay the mines without advertising their position by the presence of a tank. This would imply that the tank battalion was used merely to transport the mines, as their personnel would only be sufficient to lay the field if the tank could bring the mines to the site.

A better solution would be to make the Divisional R.E. responsible. Some of them would be with practically every detachment the division may make, and will, therefore, always be available. The work is of a type for which they are trained and they have personnel for laying.

Additional transport will be needed to carry the mines. This would be necessary whatever unit was responsible. Where the requirements of secrecy do not prevent it, the actual work of laying would be much quickened if the mine carrier could move over the ground where mines are being laid. This points to a track vehicle of some description. The present transport of the Field Companies is H.T. and the introduction of M.T. would complicate matters. But it is difficult to see how this can be avoided. The trend of transport developments is towards complete mechanicalisation. But the process is one of gradual evolution, and until it is finished the difficulties of mixed transport must be accepted. Presumably the mechanicalisation of Field Companies will be more or less concurrent with that of the infantry, and then the use of a cross-country M.T. vehicle as mine carrier is clearly indicated. For the present we must make the best of what exists. If we use H.T. to avoid mixing the types of vehicles, the resulting effects upon the speed of mine laying must be recognised. If we accept the disadvantages of mixed transport the cross-country M.T. vehicles will enable mine fields to be laid more rapidly.

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PROFESSIONAL NOTE.

RAISING WATER FROM DEEP WELLS.

The known methods of raising water from deep wells and bore-holes are described in *M.M.E., Volume VI, Water Supply.*

The Plate shews in rather greater detail how an electric sinking pump equipment might be used with the P.E. Lorry. Outline designs for two sizes of pumps have been prepared by Messrs. Allens of Bedford as follows:

(*a*) ITEM 1. One 5½" "Conqueror" vertical deep well pump with cast iron pump casing, bronze impeller and steel shaft fitted with renewable bronze sleeves.
20 ft. of 5½" Armoured Suction Hose with gunmetal strainer.
Cast iron Pipe Framework and pulley.
One 5½" Sluice Valve.
One 5½" Non-return Valve.
One "Allen" 40 h.p. 110 v., 1800 r.p.m. semi-enclosed drip-proof, vertical motor.
One drum type starter complete with Ammeter.
One alarm float.
Capacity—500 g.p.m. against a total head of 150 ft.
Total price £465 Stg. nett.
Extra price if pump casing of bronze £24 Stg. nett.
Extra price if pump motor submersible £140 Stg. nett.

(*b*) ITEM 2. One 4" "Conqueror" deep well pump with cast iron pump casing, bronze impeller and steel shaft fitted with renewable bronze sleeves.
20 ft. of 4" armoured suction hose with gunmetal strainer.
Cast iron pipe framework and pulley.
One 4" sluice valve.
One 4" non-return valve.
One "Allen" 22 h.p. 110 v., 2100 r.p.m., semi-closed. drip-proof, vertical motor.
One drum type starter complete with Ammeter.
One alarm float.
Capacity—240 g.p.m. against a total head of 150 ft.
Total price £375 Stg. nett.
Extra price if pump casing of bronze £18 Stg. nett.
Extra price if pump motor submersible £80 Stg. nett.

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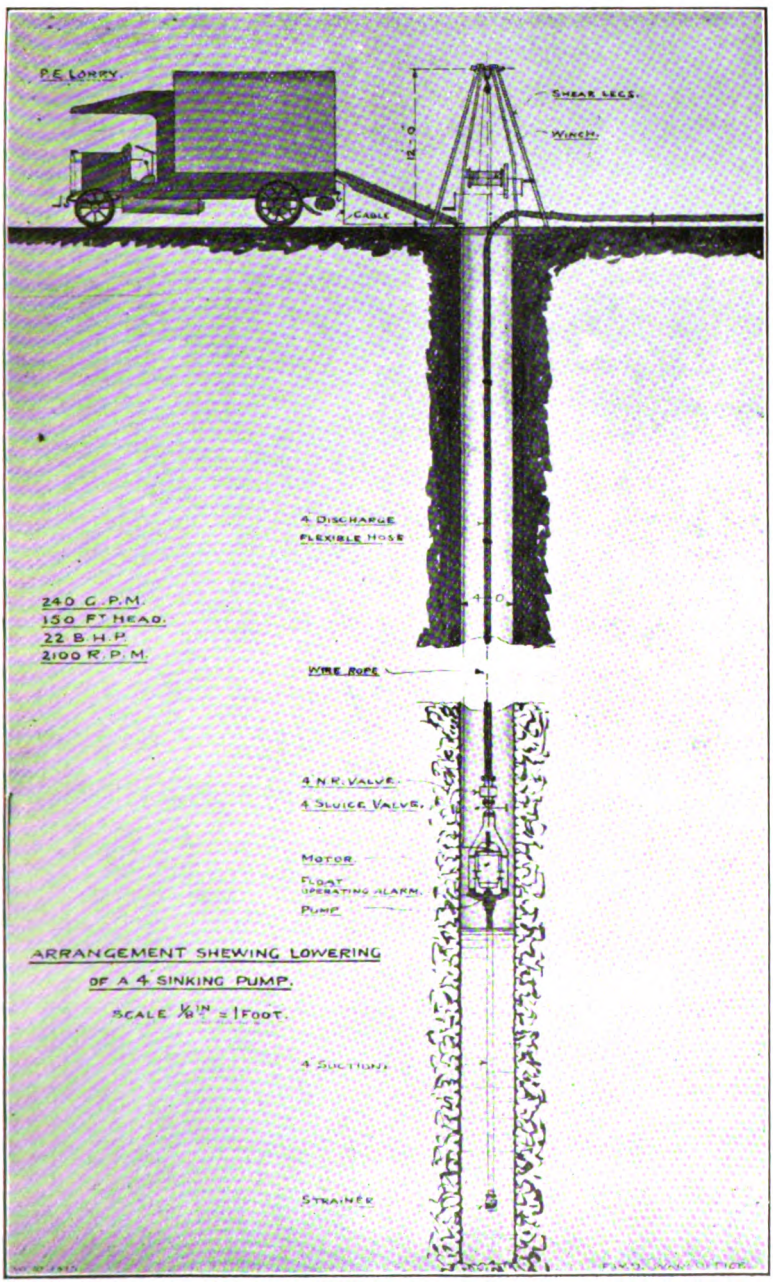
RAISING WATER FROM DEEP WELLS.



ARRANGEMENT SHEWING LOWERING OF A 4 SINKING PUMP.

SCALE $\frac{1}{8}$" = 1 FOOT.

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Installation would be effected in the field as follows:

Lorry containing gear drives up to well head, wooden skids, shear legs and winch are rigged, pump unit is slid down skids and lift taken by shear legs, pump suction connected, pump lowered down well, rising main being added as necessary and electric cable connected and paid out, lowering ceases on electric float working, pump started.

The arrangement seems to possess advantages for raising comparatively large quantities of water in a hurry in the field. It would have been of inestimable value for Sucrerie wells in France, but although specified and demanded such equipments were never forthcoming.

The advantages of this gear may be explained by stating the impossibility of using other types under certain conditions.

(*a*) CARUELLE OR BELT ELEVATORS.
Cannot be used if there is much obstruction in the well, e.g., effects of demolition.

(*b*) AIR LIFT.
Not enough submersion is available.

(*c*) DEEP WELL OR BORE-HOLE PUMPS.
Not enough time to install or get barrels up for repair.

(*d*) ELECTRIC PUMP OF HORIZONTAL PATTERN FIXED AT BOTTOM.
Not enough room and time to install.

The arrangement shewn on the plate has the very definite advantage in that it can follow the water level. It would also be of value for deepening or aditing wells in peace or war.

H.S.B.

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MEMOIRS.

THE LATE SIR MONTAGU OMMANNEY.

As the oldest friend and contemporary of the late Sir Montagu Frederick Ommanney, I have been asked to add a few personal notes to the Memoir of him published in the December issue of the *R.E. Journal.* Sir Montagu was educated for some 4 years at a school in Boulogne prior to joining Cheltenham College, whence, in July, 1861, he passed into Woolwich at the age of 19 as 45th out of 247 candidates. But for his weakness in mathematics he would have taken a much higher place, both on entering and leaving the R.M.A.

In French, he took a very high place, scoring a percentage of 87.4 of the possible marks obtainable, but it was as a draftsman that he excelled all his competitors, gaining the drawing prize on leaving Woolwich in December, 1863, as 13th Sapper out of a batch of 63 cadets. At Chatham his recreations were yachting and boating and he rowed in our "batch four," which greatly distinguished itself on the Medway. On leaving the S.M.E. in 1866, where he was the first recipient of the "Fowke" medal, he was selected, on account of his great ability as a draftsman, for special duty at the War Office and Admiralty. For the same reason he was again selected in 1871 for the post of Instructor of Topography at the R.M.A. In 1874 Lord Carnarvon, the Secretary of State for the Colonies, being on the look out for a private secretary, asked Colonel H. Y. D. Scott, R.E., if he happened to know of any young R.E. officer likely to be suitable. Colonel Scott at once named Lieut. Ommanney, with the result that the post was offered to and accepted by him, thus transferring him to an entirely new sphere of work.

That Ommanney succeeded in gaining his new chief's confidence is shown by the fact that when Lord Carnarvon vacated the Colonial Office in 1877, he appointed him as 3rd Crown Agent in the Crown Agents' Office, where he remained for the next 13 years, until Mr. Joseph Chamberlain offered him the onerous and responsible post of Permanent Colonial Under-Secretary of State.

Sir Montagu was most unwilling to accept the offer and represented that at his age (58) he was much too old to undertake fresh work of such magnitude, and strongly urged that a younger man should be selected.

Mr. Chamberlain, however, would not listen to these arguments and replied that he considered himself a much better judge of what was needed than anyone else could be and insisted on compliance with his wishes.

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For the next seven years Sir Montagu worked practically night and day without intermission; the strain unquestionably telling on him and seriously weakening his magnificent constitution. He retired in 1907 at the age of 65, a man worn out in the service of the State. He subsequently devoted himself to sketching, carpentering and gardening, in all of which he excelled.

In an appreciation of Sir Montagu in the *United Empire*, Sir Charles Lucas records that "he was an excellent man of business and combined great business capacity with good temper and great kindliness."

This is indeed the keynote to his character.

"Monty," as he was affectionately called by all his contemporaries and intimates, was never known to lose his temper, whilst he would always go out of his way to do a kindly action or a good turn to anyone. He was beloved by his school mates and his contemporaries at Woolwich and Chatham, whilst his subsequent career shews that he invariably gained the confidence and affection of his chiefs and of all those with whom he was thrown in contact.

As Doyen of the Kings-at-Arms, he was noted for his courtly bearing and his intimate knowledge of all matters of detail of their somewhat intricate procedure. It was with the deepest regret that failing health at length compelled him to resign his connection with the business of the Order of "St. Michael and St. George," with which he had been so long and honourably associated.

Many indeed are the paths of distinction open to Officers of the Royal Engineers, but it is rarely that these lead to such specially distinguished work in the Civil Service as fell to the lot of our old friend "Monty."

He seized the opening when it offered and left a record of which our Corps may well be proud. His services were rewarded by the G.C.M.G., the K.C.B., and the I.S.O., but what I think he loved best was the feeling that he had not an enemy in the world, and that all those who knew him held for him the deepest affection and esteem.

J.W.O.

COLONEL A. R. REYNOLDS.

The initials of Colonel Arthur Reynold Reynolds, who died suddenly at Wimbledon on the 16th September, 1925, will be familiar to the readers of the *Royal Engineers Journal* as those of the very able reviewer, for many years, of the *Revue Militaire Générale* and the *Revue Militaire Française*, whose last contribution appears in the present number of our Journal. Colonel Reynolds was born in 1864 and educated at Lancing College and Brakenbury's. He entered the R.M.A. in 1882 and was commissioned in the Corps in

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1884. He served in many stations at home and abroad, including India, where his chief work was the Bangalore water supply. In 1900-1901 he took part in the Boxer Expedition in China and received the medal. Promoted Colonel in 1913, at the outbreak of the Great War he was under orders to proceed to Malta as Chief Engineer, but his orders were cancelled and he was eventually sent to Salonica, where he served in 1915 and 1916. He was afterwards employed at Plymouth until the end of the war and then retired. The Editor desires to pay a grateful tribute to a colleague whose kindly consideration and long-suffering courtesy will always remain a pleasant remembrance.

F.E.G.S.

BOOKS.

HISTORICAL ILLUSTRATIONS TO FIELD SERVICE REGULATIONS (Vol. II).

By BT. MAJOR H. G. EADY, M.C., *p.s.c.*, R.E. (Sifton Praed and Co.) Price 10/6.

Major Eady has compiled a reference book of not too forbidding proportions—which will be of value to all military students, and not only to those young officers who are starting on the study of Military History.

In his preface, he says, "The main difficulty to most people seems to be to know what to read, where to look for a particular type of campaign, battle, or incident, and how to apply the illustration to the manual concerned. This book . . . . . is not intended as a crammer's 'potted history' for the purpose of passing examinations. It is hoped, on the contrary, that by seeing examples from all periods of history, the reader may become interested in the study of the evolution of war as a whole rather in that of a single campaign for examination purposes, and that in this study he may be able to evolve a logical process of thinking as to the future."

The author has read widely, and has had experience in trying to instil into others the knowledge he has gained. He has the gift of being able to condense into a few lines the essence of the examples he has selected for illustration. In some instances, perhaps, he is too brief, due, no doubt, to the limitations he has set upon himself with a view to keeping the book to a reasonable size. It is to be hoped that Major Eady will be encouraged to produce a second edition, and find space to elaborate some of the references. He has done well in recommending his readers to such volumes as Callwell's *Small Wars*, Villiers Stuart's *North West Frontier Fighting*, and the official *Operations in Waziristan*, 1919-1920, if they wish to study "Warfare in undeveloped and semi-civilized countries," and he has therefore omitted all further reference to this subject.

As a case in point, it is not much help (vide p. 89) to say regarding the "Position of Reserves"—"Again note the difficulties of the Allies as a result of the faulty dispositions of the French reserves at the outbreak

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of war (1914.)" The young officer will not be able to dig out the information for himself: it would be a task of some difficulty even to the experienced student. There are a good many examples of this assumption of knowledge on the part of a reader, and the book would have a greater value if the author always gave the gist of the situation, or a definite reference to some book from which the information can be obtained.

In another illustration, Major Eady has given a certain amount of useful information, but not enough to satisfy a thinking reader. On p. 144 he quotes Callwell's *Small Wars* to illustrate "Disasters due to lack of outpost precautions." Referring to the disasters to small isolated British columns in the latter part of the South African War, Callwell rightly attributes them to the failure of the outposts. It would help the student if Major Eady explained in what way they failed, and suggested the remedy. One of the most successful British Commanders of irregulars in the war—General Rimington—made it a rule never to camp two nights in the same place if there was any likelihood of Boer Commandos being in the neighbourhood. He was fully aware of the shortcomings of irregular troops in outpost work, and never risked surprise. At dusk he moved his column to another previously reconnoitred camp, in some cases only a mile or two away. At first there was much grousing at leaving a comfortable camp to move, generally in the opposite direction to which he would appear to leave the camp if observed, only a mile. But the men soon realized that it was worth it, and it became second nature to them to apply the same principle to their own outpost pickets. The Boers never attempted a serious attack on a halted column unless they had been able to reconnoitre thoroughly in daylight. The disaster to a small yeomanry column in the Harrismith district in December, 1901, was due to its remaining stationary for several days. The Boers were able to reconnoitre it at leisure, and made a night attack on what to all appearances was the safest side of the position, overpowered the picket and got into the middle of the camp before their presence was even suspected.

A concrete example like this would never be forgotten even by one who had not had experience of active service.

There is a note on p. 127 which requires a little further explanation. Major Eady says :—" Note the danger of being caught in march formation, as exemplified by the Battle of Magersfontein." The reader might be inclined to regard this as merely a warning not to risk being caught in march formation. The Highland Brigade at Magersfontein had made its approach march *by night*, and was late in deploying. The incident is more applicable to " Night Operations," p. 208, under the heading, " A night advance and an attack before dawn."

On p. 160 speaking of objectives, Major Eady limits himself to saying " How many of the battles in the Great War became struggles for some dominating feature," and he gives a list. But he gives no reasons why the struggle centred on these features. The main objects of both sides were generally to obtain artillery observation and cover from view for the reserves. It was not always a case of " Here is a tactical feature! It must be captured." The Germans, especially at the beginning of the

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War, were much quicker than we were in recognising such features and were allowed only too often to retain them. Even when they failed to capture them in a general attack they soon realised their importance and were not satisfied till they had captured them. Gradually, we and the French learnt our lesson, and this resulted in the desperate struggles he mentions. He might in this connection have mentioned an occasion on which it was decided that a tactical feature must be surrendered, *e.g.*, General Byng's decision to withdraw from the high ground about Monchy-le-Preux in order to shorten his line during the German offensive in 1918. He had the courage to do this, although he knew well what it meant—loss of observation and the whole slope to Arras in full view of the enemy.

The comparison of the German strategical plan in 1914 (pp. 164, 165) with the manœuvre of Alexander at the Battle of Arbela in 331 B.C. is rather far fetched. It might tend to confuse the young student, struggling with the definitions of tactics and of strategy, and further, the manœuvre of Alexander was only possible in the absence of artillery. Arbela would be a good example to quote for the study of the evolution of tactics in view of modern developments.

In any future edition the Chapter on "Information and Reconnaissance" might with advantage be enlarged. So little is printed on the subject of Information and Intelligence that the student is hard put to it to know where to study the subject. For instance, on page 101 no mention is made about leakage of information from the use of telephones, and the elaborate arrangements for overhearing and countering. The Germans were first in the field, but as usual we probably bested them in the end.

The subject of fighting by the map and not by the ground might be mentioned in this chapter. Two glaring instances recall themselves to mind—the existence, or non-existence, of "Greenland Hill," north of the R. Scarpe in the fighting in front of Arras during the last ten days of April, 1917; and a similar inaccuracy in the formation of the ground as shown by the map which led to several unsuccessful attacks south of Arras, north of the Bois du Vert and "Hook Trench," in May, 1917. In both cases it was a long time before it was realized that the contouring of our maps was wrong.

The importance of forwarding captured documents *immediately* to higher authority was exemplified in the case of "Greenland Hill." A German map, taken from the same source as our map, but corrected, was taken off a prisoner by a medical orderly and kept by him for two days. In the meantime another attack had been made by our troops, again without success. Had the information been available earlier heavy losses would have been avoided, and the probability is that the attack would have been successful, as it actually was in the other case when the true configuration of the ground had been realized by personal reconnaissance.

The more one dips into the book, the more is one tempted to read up the detailed accounts of the incidents referred to. That is the intention of the author, who is to be congratulated on achieving the object with which he set out on his work.

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A useful list of reference books is included. It is not quite complete even for the young student, and a notable omission is Wood's and Edmond's joint history of *The Civil War in the United States*, 1861-5, a standard work on that campaign.

The maps, always a difficulty because of the effect on the price of the volume, are adequate, but it would facilitate reference if those in the pocket were each numbered *on the outside* when folded. The paper might also be a tougher quality.

It is to be regretted that there is no index. Even an index on the headings of *F.S.R. Vol. II*, with references to the pages of the book on which they are discussed would be useful, because Major Eady's work is one which the student will constantly have to refer to.

H.B-W.

AN ACCOUNT OF THE BATTLE OF LIAO-YANG.

By MAJOR-GENERAL SIR W. D. BIRD, K.B.E., C.B., C.M.G., D.S.O. (Gale and Polden.) 3s. 6d.

THIS little book has been produced for examination purposes, and will prove of very great value to those working for promotion examinations or the Staff College. The operations of the two rival forces are dealt with separately. In this way the author presents a very fair view of the situation as it appeared to the opposing commanders at various times during the battle. Essential details of topography, strength of armies, moral factors, are all given, and the courses open to the commanders fully considered. In discussing alternative plans frequent references are made to *Field Service Regulations*, and the principles laid down in those regulations form the basis of suggested plans, and of the criticism of the action taken. The various situations as they presented themselves to the commanders at the time are illustrated by ten sketch maps, which have the great merit of shewing fairly well what is essential, and leaving out superfluous detail. The elimination of topographical detail may, perhaps, have been a little overdone, but no one will be sorry that the author has reduced the difficult place names to a minimum. Read in conjunction with the author's earlier strategical study of the whole war, the book may be confidently recommended to all students of military history, especially those preparing for examinations.

About 50 questions on the application of *F.S.R.* to the events of the battle are added, and the student is left to work out solutions for himself.

R.P.P-W.

LETTERS OF A ONCE PUNJAB FRONTIER FORCE OFFICER.

By COLONEL J. P. VILLIERS-STUART, C.B., D.S.O., O.B.E. (Sifton Praed.) Price 5s.

THIS eminently readable little book is in the form of a series of letters from an uncle to his nephew, who, writing from the great frontier town of England, has asked to be told all about fighting on the North West Frontier of India.

The nephew is fortunate in his parent's brother, as few people know

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more about the subject than Colonel Villiers-Stuart, formerly an officer of one of the most distinguished "Piffer" regiments, Coke's Rifles.

The first letter deals with the characteristics of the Pathan, the nature of the country he inhabits and the distribution of the various Afghan and Frontier tribes. Our control of the inhabitants of the Independent Territory which forms an ineffectual buffer between Afghanistan and British India is discussed. Our influence is at present exerted in a minor degree through the personality of Political Officers and in a greater degree through the grant of periodical subsidies.

The difficulties of extending our frontier up to the Durand Line are represented. There are some 500 miles of it, practically roadless, and the cost of making frontier roads is enormous.

The alternative policy, of withdrawing to the Indus and abandoning of all the British subjects to the west of it, who look to us for protection, is dismissed as unthinkable. Yet such a step has been advocated by at least one popular daily paper.

The two standing menaces to peace on the frontier are from the Independent Tribes and Afghanistan.

Danger from the former increases as the power of combination grows. In the old days we seldom had more than one sub-tribe to deal with at a time, but now conflict with one sub-tribe may entail hostilities against the whole tribe.

Afghanistan is a small country of about five million inhabitants, yet past history shows that war against it is not to be undertaken lightly. The first Afghan War was a military disaster relieved by one ephemeral success at the end, it was also a political failure. The second was a military success qualified by at least one bad defeat and again a political failure. The third was a doubtful military success, and is indeed regarded as a victory by the Afghans, but it had at least one important political result in that a successor to Cavagnari has been established at Kabul.

The forces we may have to face in a war against Afghanistan are the regular army of ten to fifteen thousand men, about one hundred thousand Afghan Irregulars and about one hundred and fifty thousand Independent tribesmen, who can always be counted on to throw in their lot with their co-religionists.

Colonel Villiers-Stuart recommends the study of the history of frontier warfare, and makes frequent reference to *Frontier and Overseas Expeditions from India, Vols. I. and II*, and to *Operations in Waziristan*, 1919-20.

The second letter deals with the conduct of military operations carried out in hill country, and the use of aeroplanes, artillery, machine guns, Lewis guns and tanks is discussed. No mention is made of the possibilities of using gas. In operating against tribesmen we have two objects in view:—To kill as many as possible; and to destroy villages, food and livestock.

The inhabited parts of the frontier are the valleys, and each valley or part of it represents the area occupied by a sub-tribe. The invasion of one valley may attract the assistance of the inhabitants of neighbouring valleys, hence it is often good policy to invade an area by several columns operating along different valleys.

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The danger of carrying out an act of military routine, such as setting a picquet, or sending out a reconnaisance party, in the same manner and at the same time day after day is insisted on. Punishment always follows sooner or later.

In the third letter the principles laid down in *F.S.R. II., Chapter XI.*, which have been derived from the concentrated experience of about 80 years of frontier warfare, are dealt with in some detail, and examples are given of the results of their observance and neglect. The great advantages which have sometimes been gained from night operations are described.

The fourth letter deals with "Protection in Movement," and the procedure evolved from years of experience for obtaining flank protection and security in front and rear is fully described.

"Camps and Protection at Rest" form the subject of the fifth letter. A diagram is given of the layout of a typical perimeter camp. Nowadays the site of a camp should, if possible, be in close proximity to an aeroplane landing ground. The questions of the distribution of the various arms in the camp, action in case of attack, camp picquets, etc., are very fully discussed.

Letter No. VI. is headed, "Attack, Defence and Destruction." A peculiarity of hill warfare is the dispersion to which any operating force is necessarily subjected. For example, a force operating from a camp against a distant village must provide picquets for camp protection and picquets for flank protection during the advance and retirement.

In operations against an enemy in the hills dispersion is necessarily entailed by the fact that all advances must be made up spurs, so that an attacking force is split up into small parties separated by ravines.

The most important duty on the line of communication is the protection of convoys. The vulnerability of a convoy depends upon the nature of the transport of which it is composed; it may consist of camels, pack mules, A.T. carts, light or heavy lorries. One three-ton lorry carries about the same load as 17 camels.

Defence on the frontier can only take the form of defence of camps and picquets, "it is impossible to picture taking up a defensive attitude, in the European sense, on the border." The destruction of villages is dealt with in great detail. The advance, covering troops, working parties, method of procedure and subsequent retirement are all fully dealt with.

The last letter is concerned with "Lines of Communication, Stratagems, etc." The lines of communication usually lie in two areas, a strip inside our border and the remainder in enemy country. In the first case the defence usually consists of regular posts with an outwork for transport, the garrison being sufficient to provide for the defence of the post and to furnish transport for convoys as far as the next post. Somewhere on the line there is a mobile force for aggressive operations. But in the hill country beyond our border, defence of convoys becomes much harder. The camps used by the striking force are adapted to take convoys, and are provided with garrisons sufficiently large to picquet the hills along the route and to provide an escort, there being central reserves at selected points. This method has the disadvantage of leaving the country

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between the posts open tc the enemy during the night and leads to " repetition " and the inevitable regrettable incidents.

A better method is to establish permanent picquets along the route with self-contained garrisons relieved every week or ten days, with central reserves as before.

Aggressive defence, however, is essential, the posts must be made so strong as to enable the garrisons to be reduced to a few men by day, leaving the rest of the men available to take part in small aggressive enterprises in co-operation with the garrisons of neighbouring posts.

Examples are given of the sort of stratagems which the enemy are likely to employ.

The book is illustrated by diagrams and by rather indifferent photographs of examples of the Khaibar, Kurram and Waziristan areas.

Any R.E. Officer whose work lies on the North West Frontier would do well to study this book.

A.H.B.

LES ENGINS D'ACCOMPAGNEMENT EN FRANCE ET A L'ETRANGER.

Par COMMANDANT BISWANG. (Berger-Levrault.) 3f. 50.

THIS book is an attempt to discover what is the weapon which the infantry should have under immediate control in order to overcome resistance which has survived the fire of the artillery and which they cannot subdue with their own arms.

The author proceeds logically to show that a weapon is required over and above the artillery proper and he deduces that this should be the " infantryman's own gun."

He then examines the arms which are available in the French Army to support the infantry, namely, the 37mm. gun and the 81mm. Stokes mortar. Their characteristics and failings are very fully set out so that the succeeding chapter, on their tactical employment, is the easier to follow. The doctrine of this employment is worked out with copious quotations from the manuals. The author divides it into two main parts, the " doctrine de bataillon " and the " doctrine de feu," which he considers to make it imperative that the weapon of the future should be at the disposal of the battalion commander and of sufficient power to be able to deal with any resistance met, including tanks.

The next chapter is devoted to the examination of the infantry support weapons in use, or under test, in Russia, Japan, England, United States, Italy and Germany. Special attention is paid to the two last named. The decision of Italy to use field guns is thought to be unwise. The German plan of using *minenwerfer* is admired, especially that part which lays down that the brigade commander should be able, by keeping some mortars under his own hand, to make his personal influence felt in the fight.

There follows a chapter devoted to the weapons of the future. The author concludes that two are required, (i) a heavy machine-gun, firing an armour piercing bullet for anti-aircraft work, and (ii) a gun-howitzer

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of at least 65mm. bore. The former he considers essential for defence against the armoured aeroplane. The latter should be a close support and anti-tank weapon for the infantry, very mobile, capable of rapid laying, accurate, powerful, ranging up to 2,500 metres, with 90° traverse, etc. This arm should be manned by artillerymen permanently attached to the infantry battalions. It is suggested that, in order to simplify the supply of ammunition, the bore should be 75mm. like the field gun. It is acknowledged that such a weapon is going to be heavy, and mechanical traction is given as the solution. Experiments are proceeding satisfactorily in France with a view to replacing the Stokes mortar by a more accurate light howitzer, and to adding a 13mm. machine-gun for use against aeroplanes and tanks. The author regrets the complication of having two types of gun with the infantry, viz., the 37mm. gun and the new howitzer.

The book is a thorough examination of the problem from the French point of view; it is interesting that the necessity for an anti-tank weapon is not stressed, and that the idea of saving casualties to personnel is ever present.

N.W.N-C.

LE MODERNISME AMERICAIN. L'ARMEE. LE MATERIEL. By Colonel G. Becker. (Berger-Levrault.) 2f. 50.

This book is a reprint of a garrison lecture given at Bordeaux in November, 1924. The author enumerates six lessons from the Great War, and goes on to show how they are being applied in America. The first half of the book deals with the principles followed in the organisation of the Army, the second half with the design of new weapons and material. This part of the lecture was obviously out of date as soon as it was delivered, and seems hardly worth producing in book form.

The author insists that the Army must be fashioned in the likeness of the Nation. The severe test of war strained to breaking point the relations between the aristocratic German army and the partially democratic German people.

The conditions of a future war are likely to apply a still more severe test. From the very outset the nation will be attacked directly, and not indirectly through its armed forces, as heretofore. To the increased strain of modern battle will be added in the soldier's mind the anxiety as to what is happening to his family at home.

Is our army in close touch with the nation? If not, how can the relation be improved? Any advance will have to come from the army, as the nation sees no necessity for it. The onus for making the advance appears to lie on the officer.

Another lesson of the Great War is that the industrial mobilisation is just as important as the military mobilisation. America is extremely favourably situated in this respect. Except for a war with Mexico, for which her regular army should suffice, she would almost certainly have time to mobilise efficiently before embarking on military operations. Moreover, she can raise an army of four million men without calling upon more than one twenty-fifth of her population. Thus, for her, the difficulty

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of adjusting the military to the industrial mobilisation hardly exists. It is very different for the nations of Europe and one of the most important problems in front of us is to find the correct formula for the most efficient utilisation of our man (and woman) power.

A large part of the second half of the book is taken up by the consideration of the use of gas. The author claims for aerial warfare and chemical warfare the peculiar characteristic that preparation for them does not entail purely non-productive expenditure. One may disagree with his statement that gas is a weapon capable of playing a decisive part but it is difficult not to believe with him that gas will be used. If sufficient people could be convinced of this, our policy with regard to gas might be reconsidered. Education is our first weapon of defence, but we deprive ourselves of its use by pretending the danger does not exist.

E.H.C.

EXPOSE SCHEMATIQUE DU FONCTIONNEMENT DES ARMES DE PETIT CALIBRE.

By CAPTAIN G. H. MULLER. (Berger-Levrault.) 5 fr.

THIS small book contains detailed information of the workings of the various patterns of rifle, light automatic and Hotchkiss machine gun, pistol and revolver, in use in the French Army.

It is intended for the use of Instructors of all grades of classes, from the regimental to the technical expert. The information in the case of each weapon is arranged in identical synoptic, almost tabular, form, the most important points being emphasised in black type. Every operation, feed, closing the bolt, firing and extraction is separately illustrated in very clear line diagrams. The book forms an excellent handbook for the Instructor, who can, without difficulty, extract such detail as may be suitable for his purpose.

The matter is very technical and of little general interest to others than those for whom it is written. It is, however, worth noting that the rates of fire which can be developed by the various weapons are given as follows:—Rifle, 8 to 10 rounds a minute; light automatic, 120 rounds a minute; Hotchkiss machine gun, 250 a minute. The two latter weapons can both be fitted with anti-aircraft sights; these are described in an appendix.

R.L.B.

A PRACTICAL TREATISE ON FOURIER'S THEOREM AND HARMONIC ANALYSIS FOR PHYSICISTS AND ENGINEERS.

By ALBERT EAGLE, B.Sc., A.R.C.Sc., Lecturer in Mathematics in the Victoria University of Manchester. (Longmans Green & Co.) Price 9s.

As some of the readers of the *R.E.J.* may not have heard of Fourier's Theorem, I propose to explain this theorem shortly, following the author as closely as possible.

Such expressions as x^n, $\sin x$, $\log x$, e^x, and others, or a combination of these, are "analytic" or natural functions, whereas "artificial" functions (a new term) are those which are arbitrarily defined as being equal to one analytic function in one part of their range and to another

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in some other part; there are also "empirical" functions possessing an irregular discontinuous graph. Fourier's theorem states that any periodic function, analytic or artificial, of period 2π can be expressed by the series.

$$f(t) = \frac{A_0}{2} + A_1 \cos t + A_2 \cos 2t + \text{etc. } ad\ inf. + B_1 \sin t + B_2 \sin 2t, \text{ etc.}$$

$$\text{Where } A_n = \frac{1}{n} \int_0^{2\pi} f(t) \cos nt\, dt \quad B_n = \frac{1}{n} \int_0^{2\pi} f(t) \sin nt\, dt.$$

the various terms, such as $A_1 \cos t$, $B_1 \sin t$, etc., are termed "harmonics," and the process of expressing a defined function by a Fourier series is termed "analysing."

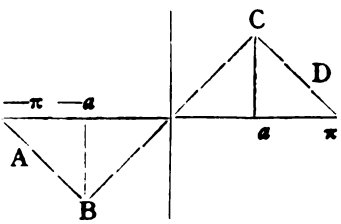
In the treatise under review the author applies Fourier's theorem to the analysis of many artificial functions met with in physics and engineering, for instance, the analysis of an odd function of t represented by

$$f(t) = \frac{bt}{a} \text{ from } t = o \text{ to } t = a \text{ and by } b\,\frac{\pi - t}{\pi - a} \text{ from } t = a \text{ to } t = \pi$$

is given by

$$f(t) = \frac{2b}{a(\pi - a)} \left\{ \sin \frac{a}{1^2} \sin t + \frac{\sin 2a}{2^2} \sin 2t\ ad\ inf \right.$$

The true graph of the function as defined is represented by ABCD, whereas that of f(t) would consist of a number of convolutions converging in general shape more and more nearly to the given figure, the greater the number of the terms of the series included in the graph. The treatise concludes with a formal proof of Fourier's theorem and with a chapter explaining how periodicities in observed data, not essentially periodic, are to be searched for.



Fourier's theorem is of great use in many physical and mechanical problems, *e.g.*, in the transmission of pulses along a wire, the flux of heat, the motion of a slide valve actuated by a set of linkages or by a cam, primarily the nature of the problem in such cases is that of the resolution of a motion known to be periodic or of the function which expresses it into its simple harmonic constituents.

Mr. Eagle's treatise is reasonably clear, requires no great knowledge of the Integral Calculus to be understood, and should be of use to physical students.

J. M. WADE, *Lt.-Col.*, B.Sc., London.

THE STRENGTH OF MATERIALS.

A treatise on the theory of stress calculations for engineers. By John Case, M.A. (Cantab.), F.R.Ae.S. (Edwin Arnold and Co.) Price 30s.

Considering the number of works dealing with stress calculations and Applied Mechanics in all its branches, which are already available, and which, collectively, deal with every aspect of the subject, there would

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not at first appear to be any place for this new book to fill; but a cursory reading of it provides its author and publishers with ample justification, and a more careful examination deepens the first impression of its great value.

The author has collected within one cover every kind of usual and unusual stress problem likely to be met with in structural and workshop practice, and deals with them in a distinctive fashion.

In a short notice of this nature it is not possible to do more than to point out what appear to be the most noteworthy features of such a comprehensive work, such as the chapters on combined stresses; beams under lateral and longitudinal loads combined; bending combined with torsion and thrust; and stresses on curved beams. Also, there is published for the first time in a standard work, Macaulay's method of estimating the deflection of beams.

Concrete-steel construction is only briefly mentioned, as it is affected by the particular argument under consideration in each chapter, and its treatment is not always fortunate (as, for instance, the paragraph dealing with long R.C. struts, which is by no means clear). The author makes it clear that he had no intention of dealing fully with R.C. construction; and it is, perhaps, asking too much to expect the general high level of the work to be maintained in this branch of the subject; but it is made unnecessarily confusing by the use of notation differing from that now regarded as standard in most books on reinforced concrete.

There are a great many examples (some worked out in full and all having the answers given), which form a very valuable feature of the book. It was the author's design to give such "examples as would make some demand on the thinking powers of the student," and the selection given contains a large number of very interesting problems, which, however, never degenerate into mere mental gymnastics, but have all a definite connection with the argument in the preceding text.

The book is designed for the use of the student reading for an honours degree, and it postulates a grounding in the subject and a sound mathematical training. It is eminently suitable for the young officer, and particularly for private reading by those taking the Cambridge Course, whom it will help considerably in digesting such points as are not immediately grasped during lectures.

A.M.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

(*August*, 1925).—*The Turco-German Command during the War*, by Commandant Larcher. The achievement of harmonious relations between allied commanders in time of war is one of the most complex problems connected with the conduct of operations, and the case of Turkey and Germany is not without interest and instruction. Commencing with an intimate co-operation induced on the one hand by Turkish admiration and respect for German methods, as exhibited in the 1866 and 1870 campaigns, and on the other by German interests in Asia Minor,

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as evidenced by the Baghdad Railway, relations between the two nations were gradually changed during the war, by German ambitions and interference, to dislike and ultimately to active obstruction from the Turkish side. Conditions were favourable for unity of command, but the Germans confused this principle with that of direct command, which, owing to the opposition of Turkish nationalist sentiment, it was impossible to impose without friction.

A Second Lesson of the War of Secession. Lt.-Col. Daille's article is continued, describing the battle of Spottsylvania and some of the cavalry raids, mainly Federal, and including Sheridan's march to Atlanta. The last is illustrated by a sketch, and the conclusion drawn is, that in spite of the powerful resources which large formations of cavalry may hope to have at their command at the present day, it is legitimate to conclude that distant missions attempted in enemy territory, on difficult ground, far from the support of the main body, are more than ever operations which involve the greatest risks in return for merely limited results. Such raids would only be justified when adopting a strategical attitude which is purely defensive. (*To be continued*).

Concerning a German Opinion. The conclusion of the article. Chap. VI calls for few remarks, as the opinions expressed more or less coincide with those of the writers of this article. It deals with French military criticisms of the proposed *loi des cadres*, many of which, to von Taysen's surprise, express a fear that the Bill is unfair to the infantry, tending to reduce its strength, overload it with apparatus, and impair its mobility. Chap. VII is, generally speaking, a recapitulation of arguments already advanced. A tribute is paid to von Taysen for the good faith which inspires his pamphlet. His reasoning is based on the spirit of the German regulations, and stripped of its mistakes and exaggerations, contains much matter which is worthy of consideration and application in France. The book is no doubt written, as already remarked, with a view to encouraging the German infantry under the enforced limitation of their material resources, and for this reason is none the less valuable as an indication of the German doctrines of war at the present time.

Schemes for the Employment of Artillery, by Colonel Picot. Before the war, ideas on the employment of artillery were vague and often incorrect, such as the statement in the 1913 regulations," artillery does not prepare the attack, it supports it." The war showed that regularly thought-out plans were necessary, and up to 1917 these plans gradually became longer and more complicated, with tables, maps and sketches decorated with the most varied colours. Fortunately in 1918 want of time for preparing such plans proved that many were unnecessary and could be replaced by general rules. German experiences and methods closely approximated to those of the French, and Lt.-Col. Bruchmuller has published a most interesting book on the subject in which he clearly demonstrates the necessity for considered schemes, but the point is that they ought to be generalized and simplified. Known methods of action would simplify the tasks of commanders, staffs, troops of other arms and of the gunners themselves; it must be remembered that many of them on the outbreak of war will not be well trained regulars. Col. Picot makes proposals for such general plans as he advocates for the attack and for

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defence, and concludes with some general remarks. His arguments are not without interest.

The Battle of Courcelles-Mary, 9th to 11th June, 1918, by Col. de Ripert d'Allauzier. This battle is interesting not only from its success, but also because here, for the first time, was systematically applied the organization of the " army battlefield " as conceived by French G.H.Q. in December, 1917. During the period of stabilization it had been customary to hold the first line at all costs, reserves being frittered away by filling up gaps in the front line as local circumstances demanded. The new scheme was to organize a position of resistance some kilometres from the enemy which he could not reconnoitre like the front line trenches, and to hold the space between this and the enemy as a covering zone with as few troops as possible carefully disposed with a view to breaking up the enemy's attack before he reached the main line of defences. A further advantage of thus retiring the position of resistance, would be that the enemy infantry would arrive before it, poorly supported by artillery, owing to its distance from the original position of their guns. Again, some kilometres in rear of this a second position was to be organised, to act as a dam in case of a breach of the first, and to be held by entirely different formations. It was essentially an organization of all arms in great depth. The position of resistance was to be held by the greater portion of the first line troops with their reserves intact and ready for counter-attack from behind, or exceptionally in front, of the position, in fact the elements of surprise and manœuvre could again be made use of in the defence. These principles had been fully grasped by the commanders of the Army group and of the 10th Army, which was attacked, also by the G.O.C's, the 36th Division (in first line of one sector of the defence) and 11th (The Iron) Division (in second line of that sector). In neighbouring sectors equally good disposition had not been made, and the enemy broke in, forming a large cavity in the French line. On the west flank of the base of this salient the resistance of the 36th Division was so firm that the 11th Division was not called upon to aid in the defence proper, and was able to effect a wheel to the east facing the flank of the German salient, into which it penetrated and recovered most of the captured ground. (*To be continued*).

The Exhaustion of the German Effectives. The continuation of Col. Pacquet's article embracing the period from mid-July to the end of August, 1918. This period coincides with the loss of the initiative by the Germans, who up to then had been able to husband their reserves by attacking only when prepared to do so. From the beginning of August the fatigue of their troops and diminution of their strength rapidly increased. (*To be continued*).

Foreign Military News. Holland. The 75 m.m. field gun is about to be improved by lengthening the barrel and modifying the carriage so as to obtain a range of at least 10 kilometres. Preparation for economic warfare has been initiated by the Minister for War, who has called for a return from all military commanders concerned of stores and munitions required on mobilization and for their replacement as required. Once in possession of this information he will approach the larger manufacturing concerns with a view to adapting their industries to supply the needs of the army.

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The draining of the Zuiderzee, commenced in 1920 and estimated to take 35 years to complete, has raised new problems of defence which are now under consideration by the Government.

Books and Reviews. L'Armée indigène nord-Africaine, by Col. Paul Azan. (Charles Lavauzelle et Cie). Col. Azan is now in command of a native regiment, and having passed the greater part of his service in Algeria and Morocco is well acquainted with Mahomedan questions. He points out the unpopularity and uselessness of conscription in Algeria; the idea of a native reserve seems to him utopian. The presence of native units in France has many and great inconveniences. He advocates a return to long service voluntary engagements with pension as a means of introducing favourable propaganda into the villages.

September, 1925. *The French Command in Western Thrace.* By Commandant Armingeat, with two maps. From October, 1919, to May, 1920, Western Thrace was administered by the Allies under the orders of a French general and then handed over to Greece in accordance with the treaty of Neuilly. As an example of what can be done in a short time to restore a distracted country, inhabited by representatives of three distinct races of different religions, and each hating the others, with customs, tax-collecting posts and telegraphs, public works, etc., utterly disorganised, the account is interesting and instructive.

A Second Lesson of the War of Secession. The conclusion of Lieut.-Colonel Daille's article. After briefly touching upon the political and economic situation and the anxiety which defeatist propaganda, introduced by the Federals into the South and among the negroes, caused to Jefferson Davis, the writer proceeds to draw his conclusions. The ruthless measures taken by Grant in devastating the country, destroying roads and industries and burning houses, combined with a rigorous blockade, slowly diminished the resistance of the Confederates. Grant's orders to his commanders were to attack at all costs. President Lincoln and the Federal Government kept him abundantly supplied with troops and stores, so that he could always rely on numerical superiority, and successive battles wore out Lee's reserves, which the possession of interior lines enabled him to utilise to advantage so long as they lasted. Grant took no risks in regard to his communications; instead of using the open roads to the west of the Wilderness he depended on the sea and navigable rivers, constantly changing his base as the advance progressed. Grant's and Sherman's tactics are contrasted, the latter depending on manœuvre for dislodging the enemy, but always failing to bring him to battle. J. Johnston's conduct of the retreat on Atlanta is commended. The Confederists' knowledge of the forests of Virginia, their individual resourcefulness, and Lee's personality, prolonged the unequal struggle. The Federal losses were enormous, but were stoically borne for sake of the Union. It was Lee's misfortune that he was faced by a Grant, but the latter cannot claim the whole credit; he was merely the chosen and trusted instrument of the Northern Government which accepted full responsibility.

A.R.R.

Les Transmissions des Grands Unités. By Colonel J. Langlois. An exercise in the organisation of Signal communications between a mobile column and its supporting division during an attack, testing the resources

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of the latest French equipment in wireless, telephones, cyclists and pigeons. "Signals can only give satisfaction if their arrangements are in strict agreement with the tactical situation and the decision of the commander; thence the absolute necessity of intimate connection and incessant collaboration between the Staff and the Signals commander."

The account of the battle of Courcelles-Mery is continued and describes how the 36th Division occupied and held the forward zone in considerable depth, and the 11th Division took up a second line in rear; but when the enemy broke through in the adjoining sector the 11th Division, on the staff of which the writer, Colonel de Ripert D'Alauzier, was serving, took up a line on the flank, which extended, toward the rear, the flank of the 36th Division. (*To be continued*).

In this number Lieut.-Colonel Paquet concludes his article on the *Exhaustion of the German Effectives in* 1918.

F.E.G.S.

REVUE DU GENIE MILITAIRE.

October, 1925.—*Permanent Fortification.* By a Foot Soldier. A proposal for a form of permanent fortification specially applicable to an extensive frontier, based on inferences drawn from field fortification in the late war. The writer suggests "*points d'appui*" spaced (with due regard to the terrain) some 1,000 to 2,000 metres apart with a second line 1,200 to 1,500 metres in rear dividing the intervals. Each such point to consist of a concrete work, covered and flanked by a ditch and/or barbed wire and containing command and observation posts with two or more each of machine guns and trench mortars all protected from direct fire. Occasional "strong points" at suitable intervals—enclosing a group of similar works. Artillery positions may or may not be prepared in advance, or be on rail and a mobile reserve be sheltered in deep dug-outs in rear of the position. The writer would so fortify the higher and more important points in peace time, leaving gaps—flanking defences (*positions transversales*) and rearward lines to be made on mobilisation.

The Fortification of Metz. Notes on certain uncompleted projects for various works.

A Drawbridge in a Bridge on Piles. Description of such a drawbridge built by the 2nd/6th Génie in April, 1925.

A Scheme with Troops carried out by the 11th Génie in April, 1925. Involving the construction of various bridges for an attack by a corps of two divisions.

A Further Note on the Drowning of Eighty German Soldiers (see June number). A detailed description of the type of raft used and suggestion that the disaster was caused by lack of longitudinal rigidity and bad watermanship in inclining the raft at too large an angle to the current.

November, 1926.—*Inauguration of the War Memorial at the "Ecole Polytechnique."* Speeches by Marshal Foch and by General Thomas (the Commandant).

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An Engineer Officer on a Mission to Turkey in the 18th Century. His letters describing a visit to the fortifications in the Black Sea. The institution of a School of Instruction for Military Engineering for the Turkish Army, and his efforts to get the fortification of Otchakow brought up to date.

The Work of the Engineers in Algeria. A summary of the public works carried out by the Military Engineers since the first occupation of Algeria in 1830.

A New Method of Gabion Revetments. For high revetments involving two or more gabions—the author claims that the insertion of a horizontal row of hurdles under each row of gabions ensures stability and avoids the necessity of anchoring back into the parapet which is often impossible A considerable economy of labour is claimed.

"*Données Numériques.*" Particulars of personnel, tools, material and time taken in executing various bridges.

December, 1925.—Motorisation des Unités du Génie.—Général Camon. A consideration of certain important operations in the past involving large movements of Engineer Equipment and Stores—mainly bridging—instancing from analagous operations in the Great War the increasing importance of all branches of military engineers.

The writer goes on to argue that the "automobile divisions" which he hopes will shortly replace cavalry divisions, will be accompanied by engineer units suitably organised—their duties being essentially to

(1) Maintain the roads and as far as possible the railways;

(2) Organise bridge heads and any holding position;

(3) Undertake demolitions.

He holds that engineer units should possess lorries for collection of local materials in preference to loading up their transport with bridging equipment or stores. The latter should be held well in rear, but organised for very rapid despatch as required. The engineer units will have plenty to do in preparing approaches, etc., while awaiting the material.

The system of Wireless Communication with and between the French Colonies.

A summary of the existing stations and history of their development. A non-technical statement of the plant installed and wave lengths used. Short wave systems are under trial, and a 5-k.w. installation maintains good communication by night (not by day) on 75 metres with Djibouti. The author goes on to discuss the future of long and short wave and cable communication and their respective advantages.

A mass production factory for ferro-concrete blocks.

A description of the blocks—used for bursting layers in dug-outs, etc.—and the lay out and organisation of the factory.

A Map Exercise.

A map exercise for the Corps Engineers in preparing a plan for destruction of communication in rear of an army, worked out in detail as regards one division.

H.G.K.W.

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REVUE MILITAIRE SUISSE.

(1925, Nos. 7 to 12 inclusive).

M. Jean Fleurier's article entitled *Une légende. La faillite de la fortification permanente* is concluded in No. 7 of the *Revue* under notice. This part of the contribution opens with a consideration of the question as to whether the defence works of Antwerp successfully played their rôle as the constituents of a great fortress. The view of the author of the original article is that the defence of Antwerp will not, in the history of siege warfare, rank as a model worthy of imitation—the same may be said of the attack on the fortress. The statesmen and leading military men in Belgium were alike disappointed in the part played by the most important of the fortresses in their country; they felt that the damage inflicted on the attacking force sent against it by the enemy was altogether incommensurate with the effort and money spent in providing the considerable armament and large quantity of munitions accumulated in the famous *place d'armes* at the outbreak of the Great War. Again, the defence put up at Antwerp had nothing like the same encouraging effect on the Belgian Army and people as had the resistance to the German advance offered at Liège. M. Fleurier accepts, however, the claim that the stand of the Belgians at Antwerp, which passed through two phases—the first an offensive and the second a defensive—had far reaching effects on the early operations in the Western Theatre. To the offensive strokes of the Belgian Army was it mainly due that German troops, which might have been utilised in the fighting on the Aisne, were retained at Brussels and in the neighbourhood of Antwerp for the purpose of guarding against an irruption of the Belgian Army from its citadel which might have jeopardised the safety of the German right wing. And to the fact that the Germans detached a considerable part of their heavy artillery for the bombardment of Antwerp was it due that they were handicapped during their outflanking movement when racing for the sea-coast. The existence of even the old detached works, provided in Brialmont's time, beyond the ramparts designed and constructed by him, produced an "intimidating effect" on the besiegers, and made them extremely cautious in their advance against Belgium's important stronghold. The slowing down generally of the German advance in the Western Theatre was of immense benefit to the Entente Powers, one of the most important of the advantages accruing therefrom to them being that the arrival of the German forces on the Yser was delayed, it is estimated, by at least 12 days. M. Fleurier's final conclusion on this subject is that, had the situation been properly handled, Antwerp could, and should, have held out longer; he thinks that, had this been the case, the reinforcements which were available could then have been moved up in time to establish the left flank of the Western Allies solidly at Antwerp, and the Germans would thus have been denied access to the coast-line. M. Fleurier next gives an interesting comparison of the sieges of Liège, Namur and Antwerp, in an abbreviated form, under 14 heads, which deal, *inter alia*, with the strategic rôle of each fortress, the resistance of the forts, the defence of the intervals between the forts, the part played by the Governor of the place, the initial plan of the enemy's attack, the action taken by the Germans against the forts, the rôle of the super-cannons, the investment,

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etc. The article concludes with an account, in some detail, of the measures taken by the enemy, after the capture of the three Belgian fortresses, to convert them into German strongholds. Before the value of this reconstruction work could be put to a test, the Entente Armies made their halt on the Armistice Line, the left of which rested near Ghent.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(1925—Tome II. Nos. 3 to 6 inclusive.)

Operations of the Belgian Army, 1914-1918. Art. 26 of the Hague Convention (1907) provides that a commander of a besieging force shall, before shelling of a defended city or town commences, give due warning to the authorities therein that its bombardment is imminent. The manner in which the Germans complied on October 7th, 1914, with the provision in question in connection with their attack on Antwerp is set out in No. 3 of the *Bulletin* under notice: it is suggested therein that although the terms of the articles were observed to the letter, yet, as shelling began almost immediately after the receipt of the bombardment notice by the Belgian authorities, the Germans really failed to give effect to the spirit of the regulation.

The position of affairs as they appeared in the light of the information available at the Headquarters of the Commandant of Antwerp's " Second Line of Defence " during the night of October 7-8th are set out (No. 3). Some of the information which reached these Headquarters was distinctly of a disturbing character; for instance, reports of the Commander of Fort No. 1 indicated that the Germans were attacking this work, and that the bulk of its garrison had, in a panic, fled therefrom after putting the guns there out of action; it was stated that only the officers and 20 O.R. still remained in the fort. However, the information now available shows that Fort No. 1 was not even threatened at this time; indeed, no part of the " enceinte de sûreté " was really attacked, or even bombarded, during the night of October 7-8th by the enemy, who was content to feel his way forward cautiously by pushing out reconnoitring patrols. No attempt appears to have been made to confirm the accuracy or otherwise of this disheartening news, but measures were at once taken to send reinforcements to Fort No. 1 and also to meet the situation which would arise should the enemy break through the line of forts; these are given in some detail in the original article (No. 3). The Commander of Fort No. 2 was directed to send reinforcements to Fort No. 1, and selected for this purpose a detachment of artillery which had fallen back from Namur; he acted thus in spite of the fact that he was fully aware that these men were in an extremely depressed frame of mind and had come to the conclusion that any further resistance to the enemy's advance was useless. In these circumstances, the transfer of these broken-spirited gunners from Fort No. 2 to Fort No. 1 was a step hardly of a nature to improve matters at the latter work. It is evident from the narrative of the operations that the troops defending Antwerp, both the Belgians and the R.N.D., were in a highly " nervous " condition, no doubt largely owing to physical exhaustion brought on by their severe bodily exertions coupled with the deprivation of sleep for an abnormal period.

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On the evening of October 7th, the Commandant of the "génie de l'enceinte" had officers standing by at the several gateways of the old ramparts in readiness to destroy the bridges over the wet ditches. Arrangements were also made by him the same evening for placing obstacles on the approaches to the old ramparts; the Boom, Malines and Turnhout roads, however, were to be kept open in order to allow the troops on the "Second Line of Defence," to retire by them into the city. The Germans began to bombard Antwerp at 0.25 on October 8th; their fire was directed chiefly against the southern suburb of the city and points of military importance in proximity to the old ramparts. The shelling, although not violent, was responsible for the outbreak of a number of fires which created anxiety; the failure of the water-supply and the fact that the majority of the inhabitants abandoned their dwellings and streamed into the streets aggravated the situation considerably.

A short account is given in No. 3 of the *Bulletin* under notice of the work carried out by the engineers in view of the contemplated abandonment of the entrenched camp on the right bank of the Scheldt. This work was concerned, *inter alia*, with the dismantling of temporary bridges and also of a boom across the river (at Perle); the destruction of pontoons and also of a second boom (at Steendorp); the destruction of a submarine-torpedo installation and also of two German steamers which had not been able to clear away from the port before the declaration of war.

At Hoboken, situated between the second line of permanent works and the old ramparts, there existed an immense installation of storage reservoirs containing very considerable supplies of motor spirit, petrol, and oil. The measures taken by the military authorities with a view to the removal of these supplies to the new base at Ostend are given. However, before the work of removal could be completed, the reports reaching Fortress Headquarters led the authorities to believe that the situation had become extremely critical; in consequence, the greater part of the motor spirit, etc., in the storage reservoirs was emptied into the ditches of the adjacent Polders. About mid-day of October 8th one of the sluices connecting the ditches in question with the Scheldt was maliciously opened and the motor spirit, etc., thus escaped into the river, where it was accidently ignited and continued its course towards the military bridge at Burght, the destruction of which by the burning liquid seemed to be imminent. Fortunately, when the flaming liquid was still about 100 yds. from the floating piers of the bridge, the tide turned and the structure was saved. W. A. J. O'M.

To be continued.

HEERESTECHNIK.

(*October, November, and December* numbers.) The first two articles in the October number, "The Motorization of the Army" and "Types of Tanks in the Light of Foreign Expert Discussion" consist chiefly of extracts from articles already published. The former is taken from Gen. Camon's article in the *Revue Militaire Française* (see *R.E.J.*, Sept., 1925) and from Col. Hemelryk's article in the *Journal of the Royal*

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Artillery, April, 1925. The second article, which quotes from many sources, mentions the Italian 5-ton tank, and Col. Velpry's proposed 600-ton tank (*Revue Militaire Française*, April, 1924, and July, 1925), as extremes of modern opinion. Summing up, preference abroad is given generally to light (6-8 ton) and medium (13-18 ton) tanks. Col. Velpry's demand for a shell-proof tank is logically sound: whether it is necessary, practicable, and useful, is another matter. Neither article is rich in new ideas.

In the October and December numbers are two articles dealing with the geological and chemical aspects of petroleum and coal. They give a good general idea of the subjects, as far as this is possible in the space.

Extracts from the Yearly Survey Report are completed in the October number. In certain parts of Germany, extensive areas of the earth's surface have subsided, owing to the dissolution of subterraneous deposits of salt. In one such area, in the Harz Mountains, stereoscopic photography was successfully employed, but no details are given as to methods, instruments, or calculations.

The New German Manual of Field Fortification, Part II, is reviewed by Major Klingbeil. "As all fortification begins fundamentally with camouflage, this occupies the first part of the Manual." While it is easy to camouflage positions from ground observers, it is much more difficult, and much more important, to conceal them from aeroplanes. The efficacy of the camouflage should, therefore, be controlled by aerial photographs taken from a height: these must be forwarded as quickly as possible to those responsible for the work, so that mistakes may be rectified. Study of aerial photographs is the practical method of studying camouflage, and accordingly the manual is liberally illustrated with them. Axiomatically, all positions must be made to blend with nature: the disfiguration of the landscape must be reduced to a minimum by a reasoned limitation of earthworks: unnatural shapes (straight lines, sharp angles, and the formation of shadows) must be avoided. Camouflage must be frequently renewed and changed according to weather and season. In open warfare, the simplest material for camouflage is tent-canvas.* By covering it over with grass, leaves, straw, or twigs, or by sprinkling it over with sand or snow: also by stretching it loosely, or by covering the edges irregularly, it can be made to match the surrounding ground. Another method is to paint it over with a gruel of mud or chalk. In the matter of dug-outs stress is again laid on the importance of constructing small rather than large ones—at most for five or six men.

As a result of experience on the Western Front, revetment of trenches is considered a disadvantage, because the materials, broken by shell-fire, block the trench. Boards or long poles should, therefore, never be used; at most, stakes not more than a metre long; above that, turf or sandbags.

In the modern system of zones defensive in depth, the parados is of

* Every combatant German soldier carries a square of tent canvas, about four feet square; cords are attached to the corners, and with the help of a few bamboo rods five or six German soldiers could at any time erect a tent. In marching order, the canvas is carried over the great coat, which is itself folded over the top of the pack.

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greater importance than formerly, as protection against "shorts" from one's own artillery. As communication trenches cannot be camouflaged, they must be so constructed that they do not betray the position of the fire trench. For example, they may be extended beyond it to a dummy position, or led alongside it, or may be connected with it by short shallow ditches. Camouflage and digging always go hand in hand, *first* camouflage, *then* dig.

Particularly important is the question of drainage. All preparations must be made at the commencement of the work. In low-lying districts, where the saturation level is near the surface, these preparations may have to be very extensive; under certain conditions the whole district must be drained and the saturation level be lowered by pumping with powerful electrical pumps.

The whole article is interesting and well worth study.

Mr. Weyl contributes a long article, *Observations on the Evolution of the Military Aeroplane Abroad*, to the November and December numbers. It is interesting as giving a general idea of the difficulties of aeroplane design, but loses some of its value through being out of date.

Extracts are given in the same numbers from the British *Manual on the Use of Smoke*. The summing up is interesting. "Almost the whole of the Manual is reproduced here, as it is very instructive. Of the Manuals yet published it is the best. The smoke candles give out a dangerous smoke, whence the remark that they will completely clear out a dug-out if lighted and thrown in. They are in fact not intended for smoke screening, but as poison gas producers. With reference to our conditions, many an opportunity in defence, particularly in minor wars, is offered for the use of smoke screens, for the protection of small units against an enemy in superior numbers, or against an enemy recklessly advancing, who possesses *every* material for war."

In the November and December numbers, reports of the German Wireless Exhibition in Berlin, and of the Motor Show at Olympia, are given. The former contains nothing of interest. As to the latter, innovations of the greatest interest from a military point of view are balloon tyres, the front axle drive, and the rapid development of the light commercial vehicle. Between them they make cross-country motor traffic a possibility.

Major Klingbeil reviews the new German manuals on *Searchlights* and *Bridging, Part III*. In the latter, particular stress is laid on the importance of the Sappers' estimate for the time required for the construction of a bridge. Difficulties in the building of heavy bridges are unavoidable; to a great extent the decisions of the higher command depend on the accuracy of the estimate, and so excessive optimism may result in the disorganisation of the whole army. Generally speaking, these two manuals do not seem to contain as much that is new as those previously reviewed.

T.H.B.

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MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*November-December*, 1925).

Heinz Zatschek completes his article "Moltke or Schlieffen?" He gives an interesting summary of the whole argument. "Schlieffen's plan, which Moltke took over on his appointment, had two defects—it reckoned with forces which would not be available, and exposed the left wing of the Army to considerable danger." (According to Schlieffen's plan, the left wing would be compelled to retreat before the French, under the assumption that no vital spot could be reached before the success of the operations on the right wing.) "Moltke, who from the first reckoned on a mass attack on German territory by the enemy, had for the moment no choice but to adopt Schlieffen's plan, to conform to which all war preparations had been more and more modified. But there is no doubt that even then he did not expect a decisive result from the German advance through Belgium, and soon was at work on a plan of his own. In 1908/09 the effects were already seen in the mobilisation orders. In 1910 the first stage of its development was complete; arrangements for transport of troops from the left to the right wing were no longer part of the programme. The remaining pre-war years formed a second stage in the developments of his plan, which, however, was never brought to conclusion. He recognised two distinct possibilities. Either the enemy's main attack was on Lorraine—he expected this, and wanted entirely to abandon Schlieffen's plan—or the enemy's main forces were directed against the German right or centre. In this case they would also be met by sufficiently strong forces to leave no doubt as to the issue. The German mobilisation orders were so arranged, that the Army could equally well be employed for a decision in Lorraine, as in Moltke's plan, or for a great envelopment, as in Schlieffen's plan. In any case, German movements were independent of the enemy's measures. Possibly Moltke's plans, even at that time, did not stop at the driving of the attack as far as the Moselle and the Meurthe, but contemplated a German breakthrough, in the event of the French failing to make an attack on that front. His manœuvres of 1913, in which the general idea was an attack on a line of fortresses flanked by two neutral states, shows that a breakthrough did not seem impossible. In 1914 Moltke tried to crystallise his thoughts into facts; it seems that up to then he had shared his ideas with no one. So it came about that even Moltke's chief of staff, Lt.-Col. Tappen, opposed certain of Moltke's measures on the ground that they represented a divergence from Schlieffen's plan. So we conclude: We should not criticise the Supreme Command on account of the changes they made in Schlieffen's plans. We must give them credit for thinking out a plan of their own, and we must regard their actions as a definite policy and not as helpless fumbling. Furthermore, we must not overlook the fact that two diametrically opposed views were represented by Moltke and Tappen, who, as an upholder of Schlieffen's plan, had to give way in everything to Moltke."

The Question of a Decisive Victory East of the Tagliamento in October, 1917, is discussed by Lt.-Col. Schwarzleitner, in answer to an article

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by General Krauss on the same subject (see *R.E.J.*, September, 1925). Krauss says that no attack to the south was made, as the intention was to drive the Italians into the sea. Actually, on October 29, the Austrian 1st and the German 5th and 117th divisions received orders to advance in a southerly direction, and they took no small part in the fighting on the next day, which brought in 60,000 prisoners. The whole offensive was based on the natural assumptions that the Italians would fight as well in defence as they had in attack on the Isonzo, and that they would utilise their reserves; both assumptions were wrong. The Germans took little interest in the Italian theatre of war, and would only sanction the employment of German troops there for a limited offensive. The sector tactics were not rigidly conceived, and were modified to suit the occasion.

As matters stood, a decisive victory was out of the question. It would even have been impossible to compel the surrender of the Italian third Army.

Lt.-Col. Wuczkowski contributes a very interesting article on *Practical Exercises for Officers*. He points out that in the small armies of to-day even a company commander seldom gets an opportunity of exercising himself in tactics with a full company; a battalion commander is very fortunate to get such a chance; for a brigade commander it is practically out of the question. And it is only by gaining confidence in such exercises that one's powers can be perfected. At present, for many officers the yearly manœuvres form the only field practice of the year, and they are too much of an examination and too little of an instruction. The author examines the possibility of finding a good substitute, and concludes that the practical method must be to instruct certain regimental and all staff officers in the conduct of tactical exercises, which should combine indoor and outdoor work, and be held at least once a fortnight. The specially trained officer works out a scheme, and then gives instruction to at most eight or ten officers, who work together to produce a solution. In the more ambitious schemes, officers of all arms should be included.

The conclusions reached are fairly obvious, yet the article is well worth reading, as it is full of the common sense and elementary psychology so frequently neglected by instructors.

The same author works out Tactical Exercise No. 3 in this volume.

Dr. Kobis contributes an article, *Practical Military Psychotechnics*. Classification of soldiers by simple tests is of value in mass recruiting for war.

The translation of the "Next Great War," by Capt. Liddell Hart, is completed in this number.

The Review of Military Science. I. *Tactics*. Under this heading are three short articles—one uncompleted—on Tanks. Capt. Fritz Heigl points out that the so-called Death Rays, which are supposed to stop motors by magnetic interference with the magneto, even if perfected, will not solve the problem of defence against aeroplanes and tanks, as magnetos are not essential to the design of internal combustion engines.

II. *Commissariat*. A long article, partly historical, on the working of the supply departments of the Austrian army, is given. It is not of particular interest to British readers.

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III. *Engineering.* A short notice of a bridging experiment is given. For building a pontoon bridge across the Danube, a motor boat was used for towing the rafts into position, the rafts being constructed down stream from the bridge line. It was considered that where strong or cross currents are encountered, the method will cause a considerable saving of time.

T.H.B.

THE MILITARY ENGINEER.

(*July-August*, 1925).—*Engineer Combat Troops as Infantry.* After stating that "The Engineer combat regiment of the Infantry division has dual functions; first and most important, as engineers for the division and, second, as infantry in case of emergency" the writer discusses a problem in which an engineer battalion has to take over the front of an exhausted infantry battalion during the course of an attack. In the suggested solution of the problem, owing to the fact that the engineer battalion is about half the strength of an infantry battalion, in order to take over the latter's front the engineer battalion has to obtain reserves from some other infantry unit. In the discussion following the article a writer points out that, with an infantry reserve available, the question whether an emergency of sufficient importance to justify the employment of engineers has arisen, must be considered.

Use of Planks in Floating Bridges. The writer gives two examples of floating plank bridges. The advantages claimed are that of rapid construction and that material can usually be found on the site by demolition of buildings.

C.G.M.

(*September-October*, 1925).—*Hydraulic Mining Problems in California.* Though of no military interest, this article on gold mining is a striking example of the harm which can be done to the community by a small section of people whose sole object is the acquisition of wealth. It is a strong argument for a measure of State control of industry. The gold-rush to California started in 1849, bringing a stampede of a hundred thousand men to that State. The first mining was done by the "panning" process, in which the silt from the river bed was washed by hand. It was soon discovered that rich deposits of gold were to be found not only in existing rivers, but also in the beds and banks of dried-up streams, and those liable to flood only at certain times of the year. To extract the gold from these localities, the hydraulic process was introduced, consisting of the application of high pressure jets of water. The sludge was directed into wooden troughs, in which the gold remained in sediment. This process proved extremely successful and developed to such an extent that up to the year 1923 something like 1,600,000 cubic yards of gravel had been worked. Open pits half a mile wide and a mile or more in length had been excavated, some to a depth of 400 feet. The bed of one stream had been raised 250 feet by gravel washed into it. By this time, the damage inflicted on river channels had caused serious interference with agriculture and navigation, and it became necessary to pass an Act

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appointing a Debris Commission, and limiting the granting of licenses to firms who undertook to arrange to impound their debris behind suitable dams. These restrictions have severely curtailed the industry, which is now in a somewhat serious plight. The Commission is at present engaged in collecting information with a view to improving matters.

Topographic and Geologic Maps. An interesting, though somewhat elementary, treatise on map reading. The Geological Survey Dept. issues four types of maps: geographic, topographic, geologic, and mineral resource. Each of these is described in turn. Illustrations of various types of terrain and their geological explanation accompany this article.

Emergency Dams at Seattle Canal Lock. This lock connects Puget Sound with Lake Union, the difference in level being 26 feet. To provide against possible failure of the gates, emergency dams have been provided. The up-stream dam takes the form of a 70-ft. span steel girder bridge carrying the sluice gates and winding gear. Normally the bridge lies alongside the edge of the lock, where a 75-ton derrick is available to pick it up in emergency and lift it bodily across the lock. The sluice gates are then lowered to engage in a concrete groove at the bottom of the lock.

Zenith light for hill-shaded maps. The Corps of Engineers is experimenting with a hill-shaded map, showing relief entirely by vertical projection. The method adopted is to project a vertical light on to a relief model of a contour map and photograph the result. It is claimed that this process gives a truer impression of the shape of the ground than the more popular method of shading a map in relation to an oblique source of light, assumed to come from some arbitrary direction. Four specimen maps, produced by this process, accompany this issue.

New "Ways" for Old in New England. Reveals the interesting fact that the Boston and Maine Railroad are seriously considering the scrapping of 1,000 miles of track, in face of competition from the automobile. The writer discusses the advantages and shortcomings of both types of transport, and concludes with a suggestion that the track, if scrapped, should be pulled up and a road surface substituted. A possibility by no means remote in this country.

What about Reserve Instruction? There are three principal ways in which officers of the National Guard and Reserve can keep in touch with military affairs. They may attend camp with regular units; they may take correspondence courses, and in some areas branch schools have now been established in the principal cities, where instruction is given by regular officers. The response has so far been disappointing.

(*Nov.-Dec.*, 1925.) *Work of the Bureau of Standards.*—Standardisation is the essence of mass-production. One is not surprised, therefore, to learn that America is provided with an unusually complete government department, whose duty it is to maintain and develop working standards of all kinds. Even so, one is scarcely prepared for the vast and elaborate organisation which is described in this article. Apart from the numerous science and research laboratories, the equipment includes model factories,

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representing many of the principal industries of the country, where problems of manufacture may be investigated on a commercial scale. The value of such an institution is self-evident. No doubt similar establishments are to be found in this country. If so, it would do one good to read about them.

Electric Power during the World War.—Owing to the heavy demands for munitions and war stores in general, the power services in many of the industrial centres proved inadequate. The inflation of prices made it impossible for the power companies themselves to embark on the construction of additional stations. State assistance became necessary, not only to finance new undertakings, but also to straighten out existing contracts which were hindering the even distribution of power. As a result of the lessons learnt during the war, there now exists in the office of the Assistant Secretary of War an agency charged with the duty of keeping in touch with the resources of the power industry, and the amount and probable location of the power needs of the country in time of war.

India and the Grand Trunk Road.—A descriptive account of a famous road and its place in Indian history from the time of Alexander the Great.

Transmission of Pictures over Wires.—Describes the methods by which photographs may be transmitted by telegraphy. Remarkably clear results can now be obtained at comparatively low cost.

Brock Development of Aerial Mapping.—Conic projection effects, altitude variation, camera tilt. These are the three causes of inaccuracy in aerial survey. The Brock Company has been experimenting in the field since 1914 and here describes some of its latest types of instruments, and the methods by which errors may be eliminated.

Synchronous Torsional Vibrations.—An explanation of these phenomena with special reference to the design of Diesel crank shafts.

R.I.M.

THE DRAGON.

As "Men of Kent" we offer our congratulations to the County Regiment on the appearance of its regimental journal in a new and attractive cover, which shows, besides the famous dragon crest, the battle honours of The Buffs from "Blenheim" to "Baghdad." The cover has been designed by Mr. Graily Hewitt, who also designed the Roll of Honour of the Regiment, which rests in Canterbury Cathedral. The February number of *The Dragon* contains, among other matter, a review of Lieut.-Colonel W. A. J. O'Meara's recently published book *Kekewich in Kimberley*, the proceeds of the sale of which are to be devoted to The Buffs' regimental charities. F.E.G.S.

CORRESPONDENCE.

British Legation, Belgrade,
December 16th, 1925.

To The Editor, *The Royal Engineers' Journal.*

SIR,

Having just read the article in the December number of *The Royal Engineers' Journal* on the "Life and Work of Colonel Clarke," by Colonel

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Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., it strikes me that the following sidelight on Clarke's activities in Russia in his early days may be of sufficient interest to warrant insertion in your next number.

In the month of October, 1925, a venerable and nearly toothless old gentleman, wearing Dundreary whiskers and the dilapidated uniform of a Russian General, came into my office and explained in very fair English that he was the Editor of a Russian Military Journal which is distributed quarterly throughout Europe to all officers of the late Russian regime by the organisation of which General Wrangel is the moving spirit, from his headquarters at Novi Sad, north of Belgrade.

My visitor introduced himself as General Ekk, and said that he had been following in the *Times* the description of our manœuvres held in England last Autumn, and confessed that, though he had been able to make a digest for his paper, there were certain terms and expressions used, which, although he had searched diligently for their meaning in a dictionary, did not appear to have much connection with modern military methods.

He had come, he said, to beg for my assistance in his difficulty, and at once asked what was a "Dragon," a "Hathi," and several other similar terms which have been coined in the post-war mint of British Army nomenclature.

Looking at his poor worried old face, which reminded me of nothing so much as Tenniel's illustration of the old man sitting on a gate in Lewis Carroll's classic, it was easy to picture what the confusion and bewilderment must have been to him whose last experience of active service was probably about the time of the Russo-Turkish war.

After I had explained away his difficulties as best I could, he began a pæan of praise on the English and more especially the English Army, and then went on to say that before the war (he did not specify which, so I was not prepared for what was coming) he had had a great friend who was an officer in the British Army by the name of Clarke, and did I know him? I replied that the name was not an uncommon one in England, and asked him where he had known him. He answered "In Russia." Some subconscious impulse prompted my next question, "Was he doing survey work?" "Yes," came the answer, "he was working on calculations for the shape of the earth."

Obviously the old gentleman was referring to Colonel Clarke, whom he must have known before the days of Plevna and the Schipka Pass.

And this confirms the story at the end of Colonel Sir Charles Close's article that Clarke's name bore a greater reputation in Russia than in his own country.

And this was a reputation worth having in a country whose Geographical Service employed continuously 300 Triangulators and 1,100 Topographers, in Eastern Siberia and Manchuria alone, from the end of the Russo-Japanese to the outbreak of the great World War of 1914.

I am, Sir, your obedient Servant,

F. GILES, *Colonel, British Military Attaché.*

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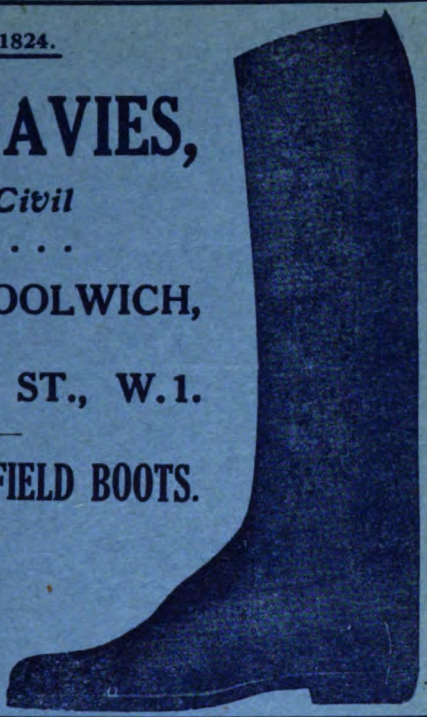

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Maj.-Gen. *Sir* Reginald U. H. Buckland, K.C.M.G., C.B. 1926

Elected.

Col. G. H. Addison, C.M.G., D.S.O. 1924
Major G. Le Q. Martel, D.S.O., M.C. 1924
Maj.-Gen. *Sir* Hugh B. Bruce-Williams, K.C.B., D.S.O. 1924
Col. H. B. Jones, C.B. 1924
Col.-Comdt. E. M. Jack, C.M.G., D.S.O. 1924
Brig.-Gen. J. E. Edmonds, C.B., C.M.G. 1925
Col. *Sir* Charles F. Close, K.B.E., C.B., C.M.G., F.R.S. 1925
Maj.-Gen. J. R. E. Charles, C.B., C.M.G., D.S.O. ..1925
Lt.-Col. R. E. M. Russell, C.B.E., D.S.O. 1925
Major R. P. Pakenham-Walsh, M.C. 1926
Col.-Comdt. H. L. Pritchard, C.B., C.M.G., D.S.O. 1926
Lt.-Col. W. A. J. O'Meara, C.M.G. 1926
Col.-Comdt. *Sir* Sydney D'A Crookshank, K.C.M.G., C.B., C.I.E., D.S.O., M.V.O. 1926
Major G. E. H. Sim, D.S.O., M.C. 1926
Bt. Lt.-Col. C. G. Ling, D.S.O., M.C. 1926

Ex-Officio.

Maj.-Gen. P. G. Grant, C.B., C.M.G., (*Cdt. S.M.E.*).
Col. P. E. Hodgson, D.S.O. (*A.A.G., R.E.*).
Col. H. G. K. Wait, C.B.E., D.S.O. (*Pres. R.E. Board*).
Col. J. C. Matheson (*A.D.F.W.*).
Col. R. Oakes, C.B.E., (*A.D. of T.*).
Col. H. St. J. L. Winterbotham, C.M.G., D.S.O. (*G.S.*).
Bt. Lt.-Col. D. K. Edgar, D.S.O. (*C.I.C.*).
Major G. C. Gowlland (*C.I.M.W.*).

Corresponding Members:

Col. H. F. H. Hertzberg, C.M.G., D.S.O., M.C., *p.s.c.*, R. Canadian Engrs..
Lieut.-Col. J. E. Duigan, D.S.O., *p.s.c.*, N.Z.S.C. (late R.N. Zealand Engrs.).
Lieut.-Col. Sir. T. W. Edgeworth David, K.B.E., C.M.G., D.S.O., F.R.S.
Lieut.-Col. A. M. Martyn, C.M.G., D.S.O., (Australian Staff Corps).

Secretary: Col. F. E. G. Skey, 1st July, 1919.

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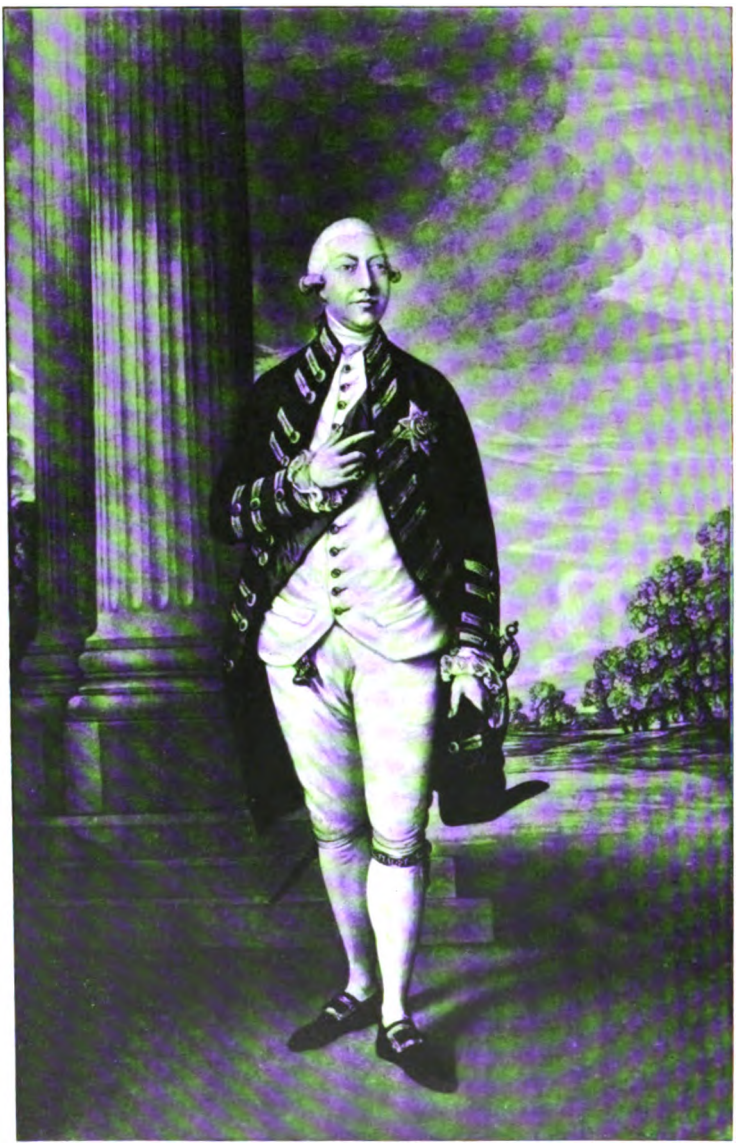

KING GEORGE III.

(After Gainsborough).

A generous and beneficent monarch, whose knowledge and love of the sciences were sufficiently evinced by the protection which he constantly afforded them, ... supplied the funds that were judged necessary . . . for the first trigonometrical operation.

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THE EARLY YEARS OF THE ORDNANCE SURVEY.

(Conclusion.)

X.—The Six-Inch Survey of Scotland and the North of England.

The End of the First Hundred Years.

The Six-Inch Survey of Scotland and the North of England.—At the end of the year 1837 the general situation was the following:—Three-quarters of the one-inch map of England and Wales had been finished; the six-inch survey of Ireland was approaching completion; but nothing had been done for Scotland, except the original sketch map of 1747-55, and an incomplete triangulation on which work had been stopped in 1825. It was clearly the turn of Scotland, and influential corporations and individuals moved the Government to approve of the execution of a six-inch map of that country. Thus, in 1837, the Town Council of Edinburgh presented to the Treasury a memorial, from which the following extracts are taken:—

"The form and position of headlands, and even of considerable islands, not only in Arrowsmith's map, but in our best charts, are erroneously given, and sometimes dangerous rocks are totally omitted. For example, the distant rocks of the Stack and the Skerry, off the northern coast of Sutherlandshire, are left out by Arrowsmith, while the important islands of Barra and Rona are misplaced both in latitude and longitude. In some books and charts the nearest distance of the large island of Arran is stated or laid down as four miles from Bute, and in others as three miles from that island. Pladda Island Light is placed as 16 north of Ailsa Craig; whereas its true distance is only 10.20! . . .

"Your Memorialists are informed, that of the great triangulation of Scotland, by which the positions of the principal objects are ascertained, the greater part was executed nearly twenty years ago, though the results have not yet been published; and that the remaining part can be soon accomplished at a small expense."

They also pressed for the general Survey of Scotland to be proceeded with. Other addresses and memorials on the subject were submitted to the Government by various public bodies in Scotland.

The question was brought to the notice of Parliament, and a motion for the production of memorials on the subject was brought forward by Sir R. Musgrave. The upshot was that a six-inch survey of Scotland and of the six northern counties of England was approved by the Government.

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Sir Henry James, then Director of the Survey, writes in 1859 :—

"The survey of Ireland was completed on the six-inch scale; and though it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties in the South of Scotland on that scale."

The triangulation of Great Britain was taken up again in 1838. In July and August of that year we find Colby, with Lt.-Colonel Robe and Lt. Robinson, on the summit of Ben Hutig (or Hutich), on the north coast of Sutherland. From this year until 1852, when it was finished, the work proceeded steadily. The observers for the first three or four years were Lt.-Col. Robe, Captains Robinson, Pipon and Hornby and Lieut. Da Costa.

A change of custom took place in 1840-41. Until then, all the observations of the principal angles were made by officers, as is still the case on the Survey of India. But in 1840, Corporal Donelan, R.S.M., observed some angles with the 12-inch theodolite in Ireland; and, in 1841, Corporal Steel, R.S.M., observed some angles with the 18-inch theodolite in Yorkshire. Thereafter, it became increasingly common to employ non-commissioned officers on this duty, and by the time the triangulation was completed it might be said that three-quarters of the total number of the angles had been observed by them. The observers most to be remembered, in this connection, are—giving them their later ranks—Sergt.-Major Steel, Colour-Sergeants Donelan and Winzer, Sergeants Bay and Jenkins, and Corporal Stewart; between them they observed at no fewer than 149 principal stations, out of a total of 228 in the British Isles.

The Completion of the Original Six-Inch Survey of Ireland.—The original object of the six-inch survey of Ireland, at its commencement in 1825, was the accurate delineation of the boundaries of counties, baronies, parishes and townlands. Later, however, it became necessary to show all the detail that could be drawn on the scale. Larcom writes :—

"At this time (1843) another circumstance had arisen. The early northern counties had not been surveyed with the degree of detail which had been attained in the south. . . The tenement valuation, now introduced for the Poor Law, required this detail. Accordingly, on the memorials of the northern counties, the Government allowed the maps to be revised."

Sir Henry James, writing in 1859, thus describes the matter :—

"We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands,

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which was at first supposed would be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We consequently had again to proceed to the north and complete the survey. . . Our parties are now finishing it—they are in Armagh. . . . And when that is finished I trust it will close the six-inch survey of Ireland."

The revision, so described, was not finally completed and published until 1863; but the original survey was finished in 1846, just before Colby retired. This original survey was complete as regards the southern counties, but in the north was only in skeleton—as laid down by the Select Committee. We have seen that the maps of the first county to be finished, namely Londonderry, were submitted by Colby to King William IV. in 1833.

So far we have dealt principally with a horizontal survey which made no attempt to show vertical relief. In the thirties this latter question came to the fore, and the advent of railways made the matter a practical one.

Levelling and Mean Sea Level.—The first lines of spirit-levelling undertaken by the Survey were those run in the year 1837, in the north of Ireland, to connect the larger lakes with the sea. These observations and those carried out between Axmouth and Portishead, by a committee of the British Association, under the direction of Whewell, in 1837-38, showed that much greater accuracy was obtained by levelling than by the observation of vertical angles. In 1839 levelling was definitely adopted in the Survey of Ireland for the purpose of fixing altitudes. The first levelling of Ireland was finished in 1843. The datum for Ireland was fixed as the level of a low water spring tide, observed at Poolbeg Lighthouse, in Dublin Bay, on the 8th April, 1837. If we compare the values based on this datum with those based on mean sea level, we shall find that all the heights on Irish maps are about 8-ft. too great.

In 1840 the original primary levelling of Great Britain was commenced; this was not completed until 1860.

The question now arose as to what datum should be chosen for Great Britain, and, after consultation with Airy, Colby caused to be carried out a series of tidal observations at 22 stations round the coast of Ireland, in June, July and August, 1842. The observations were taken on a tide-pole every five minutes, for one complete tide a day. The results confirmed the opinion that mean sea level would form the best datum. To obtain this datum for Great

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Britain, tidal observations were made at the Victoria Dock, Liverpool, in 1844, taking the mean of high and low water. These observations were made at five-minute intervals, extending over about an hour around high and low water, and lasted from the 7th to the 16th March. Owing to the short period during which observations lasted, the old Liverpool datum was not minutely accurate; but it served its purpose well for nearly eighty years. It is now superseded by the new datum, which is mean sea level at Newlyn, in Cornwall, "as derived from the mean of the hourly readings recorded by the automatic tide gauge there for the period of six years from 1st May, 1915, to 30th April, 1921." It is of some interest to note that the mean of six years' readings differs from the mean of 10 years' readings (up to April, 1925) by less than a tenth of an inch, and that the probable variation of one year's mean from the mean of the ten years is about half an inch. This amount is about the same as the probable annual fluctuation found at nine tidal stations in India, which is 0.6 inch. The next step, after having settled the datum and the method of determining the heights of the level net-work, was to devise a suitable system of showing the ground-forms.

Contours.—A contour has been defined as "the outline of the intersection of a gravitational equipotential with the irregularities of the earth's surface"; but even this somewhat formidable definition is not quite correct, having in mind the actual method in use. The *Oxford Dictionary* defines a contour line as "a line representing the horizontal contour of the earth's surface at a given elevation," and this description, though not minutely exact, will do for most purposes. The same Dictionary quotes ***Ansted***, who, in his *Geology* of 1844, remarks on "the laying down on the map a system of what are called contour-lines; by which is meant lines of equal altitude above a certain standard level." According to Colonel Berthaut:

"La première idée des courbes de niveau remonte, en réalité à 1729. A cette époque déjà, l'arpenteur hollandais Cruquius avait imaginé de définir le lit de la Merwède à l'aide de courbes d'égale sonde. En 1737 Philippe Buache représenta de même le fond de la Manche. Mais, comme le faisait remarquer la Commission de 1802, c'est le Corps de Génie qui le premier, et bien avant les ingénieurs géographes, sut définer les accidents du sol par des courbes de niveau. . . . Le chef de bataillon du génie Haxo, dans ses projets de 1801 pour Rocca d'Aufo, employa le premier régulièrement les sections horizontales, à l'échelle de 500e."*

To this account may be added that Buache, above mentioned, "published a contoured map of the English Channel, but did not

* *La Carte de France.* Colonel Berthaut, Service Géographique de l'Armée, 1898. Vol. I., p. 139.

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touch the land, 1752. Ducarla is said in 1771 to have developed the idea practically, not knowing of Buache's work."†

We have seen that, in 1777, Dr. Charles Hutton, F.R.S., for the purpose of determining the attraction of Schiehallien on the plumb-bob, "fell upon" the method of "connecting together by a faint line all the points which were of the same relative altitude."‡ Hutton's idea was evidently quite independent of those quoted above, and Hutton's appears to be the first application of the idea to the land surface. But, however that may be, it was forgotten.

With regard to the date of the first use of contouring in this country, Larcom, in a letter to *The Civil Engineer and Architects' Journal* of November, 1843, states that contours have been applied to the representation of ground "for more than half a century (*i.e.*, before 1793), especially to military plans, where the relative command of ground is of great importance; for which purpose all officers of engineers are instructed in contouring."

In the Ordnance Survey Library, at Southampton, there are four volumes of manuscripts, bound together by Sir Thomas Larcom, dealing chiefly with contouring and levelling. In three of the volumes there are prefaces in Larcom's handwriting. These volumes give a very clear history of the adoption of contouring by the Ordnance Survey, especially in Ireland. In the introduction to the first volume, which has the title, *Contouring*, 1841-45, Larcom writes:—

"A general map on the scale of one-inch to the mile was an original portion of the Irish Survey ordered by the House of Commons, but it was properly deferred until the outline survey on the larger scale of six inches to the mile was sufficiently advanced to furnish the reduced outline in readiness for the delineation of the ground upon it. In 1831 it was so, and the best and most experienced officer on the English Survey was transferred to Ireland to take charge of it (Lieut. Dawson). He was stationed at Londonderry, around which the six-inch work was already completed. I had myself been employed on the English Survey and was very familiar with the general map of that country. But my subsequent experience on the Irish Survey had led me to the conviction that the more perfect outline obtained by the Content Survey in Ireland required that the hills also should be inserted by a more rigorous process than the sketching used in England. This could, I thought, be obtained in no way so well as by the introduction of lines of equal altitude, in the French mode, which Mr. Dawson (the father of Lieut. Dawson) had taught to the cadets by the name of contouring, but which had never been practically used in England for the maps. For this purpose I was anxious that Lieut. Dawson should adopt contouring, and I was allowed to supply him with outline maps and proper instruments. It did not

† From a note by Colonel H. G. Lyons, D.Sc., F.R.S.

‡ *Philosophical Transactions*, 1778.

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then succeed, because Dawson was soon called away to a succession of temporary duties in England . . . till, in 1838, he was permanently withdrawn to a civil situation."

It will be noted that Larcom attributes to the elder Dawson the introduction of the word "Contouring." This would, perhaps, be about 1800.

In 1841 Larcom was sent

"A young officer of no experience whatever, who had never been employed on the Survey at all, he was forced upon me by Colby, but was so entirely unsuited to the work that it became necessary in 1843 to relieve him. Thus more valuable time was lost. But during the 12 years which had elapsed since 1831, practical science had greatly advanced and the value of correct topography had become more and more appreciated. Railways alone, which during that time had become introduced, were sufficient to enforce the necessity for correct altitudes and differences of level; and contours had therefore assumed yet greater and more general importance. They had now become a necessary adjunct to the six-inch plans themselves. The Ordnance, however, remained opaque, and it required a Parliamentary Commission (Sir J. Young's, 1843) and the representation of scientific and local bodies to impress on that heavy Board the necessity of allowing us to keep pace with the advancing knowledge of the age. Gradually, however, even this was accomplished, and when Lieut. Leach succeeded to the duty in 1843, the field was nearly clear for him to move freely. The contouring had been begun at Londonderry, and been dropped. Then, on a whim of Colby's, moved to south; then to Kilkenny, with, in that case, a good object, viz., an effort to produce the contours in sufficient time to insert on the six-inch sheets, then in process of engraving . . . the young officer . . . was succeeded by an admirable man (Lieut. Leach), but too late to overtake the six-inch work. . . Leach began systematically to carry on the two duties together (revision and contouring), and he did both satisfactorily. Much energy, in spite of many checks, gradually succeeded, and all continued to go on well till 1846, when I left the Survey."

In Larcom's second volume of letters he says that this part of the story

"Begins with the movement at the British Association in favour of contouring, at the Cork meeting in 1843. Next, the desire for more accurate knowledge of levels in aid of the sanitary improvement of large towns in England in 1844—for which our (Irish) contoured sheets were produced as examples. Then, the movement of the Northern Irish Counties for revision as well as contouring. The value of contouring had, in fact, become fully recognised, and the Ordnance could no longer withhold their assent."

The volume also contains some correspondence relating to the proposal to have the cadets at Woolwich instructed in contouring; nothing effective being done till Captain Stotherd, who had been trained on the Irish Survey, became Professor. "It was then combined with Surveying, and continued (1839 to 1843)."

But, perhaps the most unexpected contents of the volume are

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the accounts of the various experiments made by the elder Dawson, Larcom and others, and show hill features on a map. The examples bound up in this book date between 1824 and 1847. We have first an inked-in field sketch by T. Budgen, as practised on the first one-inch Survey of England; then essays in light and shade by Larcom in 1824; then some brush and pencil drawings by Dawson and a fine bit of chalk lithography; horizontal hachures; close contours; layer shading of County Kilkenny; and layer shading with the relief emphasised, of 1843—we might have had layered Ordnance maps as early as that year; hills in plastic low relief; and a curious, but effective, example of contours as fine raised lines. These experiments are worth study and almost deserve a monograph to themselves. They show that our predecessors were much alive to the importance of the subject, and that eighty or ninety years ago there were no methods, which we practice now, with which they were not acquainted, and that they had also tried others which we have forgotten.

In Great Britain contouring was begun about the same time as in Ireland. "Contour parties" first appear in the returns in 1843.

In the midst of all this technical activity there came an administrative change which was to affect the future of the Survey very materially. This change, the removal of the headquarters from the Tower to Southampton, came about chiefly as a result of a fire in the Tower. And this must now be described.

The Fire in the Tower of London.—The offices of the Ordnance Survey, the drawing room and the stores, were housed in some buildings touching the upper old storehouse and to the east of it, in the Tower of London. This storehouse was to the north of the White Tower, that is, on the far side from the river. The upper old storehouse is so described in a map drawn about 1685; later it was known as the Grand Storehouse. It was, in fact, an Armoury which had been begun by James II and completed by William III. This Armoury was destroyed by a fire which broke out on the 30th October, 1841. The following extract from the *Times* describes the circumstances:—*

"1st November. On Saturday night last at 10.30 p.m. fire broke out at the Round, or Bowyer, Tower to the north of the Stores.

"11 p.m. The fire reached the Armoury or Store House.

"11.20 p.m. The roof fell in.

"12.30 p.m. Heat was so great between the Armoury and the White Tower that some of the engines were burnt.

"1 a.m. All attention was directed to save the White Tower and St. Peter's Church. The lead on the White Tower was melted. 'By this time a plentiful supply of water had been obtained.'

* The writer is indebted to Major C. J. ffoulkes, B.LIT., F.S.A., Curator of the Armouries, for this reference.

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"2 a.m. Some signs of abating. 'Prior to this a new cause of alarm arose in the Map Office. This was in very great danger, which was averted by the exertions of the firemen, and the very efficient assistance of the troops.'

"3rd November. Brick Tower totally destroyed.

"5th November. At 10 o'clock last night the fire was still raging in the west wing of the building.

"6th November. 'The Map Office, which occupies the north-east corner of the Quadrangle, and which has suffered very materially from the action of the fire, is now quite deserted. It had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton, and many of the presses and fittings, having been seriously injured by hasty removal on the night of the fire, the Board of Ordnance have directed that suitable apartments shall be immediately prepared for them at the above port.' The Board of Ordnance Meeting: Colonel Peel in the Chair.

"9th November. Wet blankets were hung over the north face of the White Tower to prevent the flames cracking the stone work.'

The chief loss which the Survey suffered was the destruction of Ramsden's Zenith Sector. The standard bars were saved; the four theodolites, the 3-ft. R.S., the 3-ft. B.O., the 2-ft. by Troughton and Simms, and the 18-in. by Ramsden, were all in the field. The "long room," where Drummond's light was first tried, which occupied the upper floor of the Armoury, was, of course, destroyed.

A small point arises as to the want of water with which to fight the flames when the fire first broke out at 10.30 p.m., on the 30th October. In the Fire Officer's report it is stated that no water was supplied by the Water Company's mains, and water could only be drawn from tanks, from the moat or from the Thames. It appears, from information kindly furnished by the Hydrographer, that it was high water about 1.45, that is, about three hours after the outbreak was discovered.

"*The Annual Register*,† describing 'the Awful Conflagration at the Tower' of London, states that: A sentinel fired his musket to give the alarm, the troops turned out, the tower engines, 9 in number, started to play, or rather, to work, and engines of the Fire Brigade hurried up from all over the metropolis. Unfortunately the tide was out and the tanks under the Tower afforded but an inadequate supply of water. By 11 o'clock the destruction of the Round Tower was complete, the Armoury was involved, there were fears for the Jewel Tower and its contents, especially when it was remembered that the keys to the cases were in the possession of the Lord Chamberlain. However, they were broken into and the 'regalia, crowns, sceptres and other valuables of Royalty' were carried to the Governor's residence. 'A new cause of alarm arose in the Map Office, which contains some very valuable maps, records, etc., catching fire. That, however, was soon got under, and all the property placed in safety.'"

It was supposed that the fire originated in the armourer's forge

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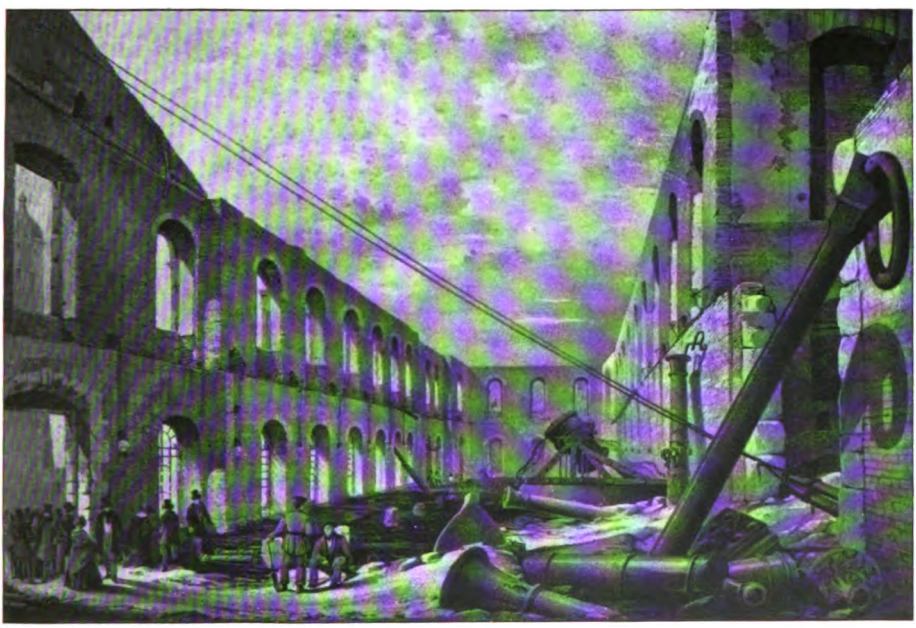

VIEW OF THE RUINS OF THE GRAND STOREHOUSE IN THE TOWER OF LONDON,

After the Fire which broke out on 30th October, 1841.

Reproduced from a Sketch preserved in the Tower, by permission of the Curator of the Armouries.

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in the Round Tower. It would appear that all the Survey maps, stores and documents were saved, except Ramsden's Zenith Sector.

The Ordnance Survey moves to Southampton.—In the extract from the *Times*, above quoted, it is stated that "it had long been the wish of the Officers of the Survey Department to remove their headquarters to Southampton;" but this desire was certainly not the official reason for the move. In the *Minutes of Evidence taken before the Select Committee on Army and Ordnance Expenditure*, 1849, occur these passages :—†

"Major-General Charles R. Fox [Surveyor-General of the Ordnance] called in; and examined.

"Sir J. Graham: You have heard the evidence which has just been given; have you formed any opinion upon the subject of that evidence? —Yes, the Map Office, which has been lately transferred to Southampton might, I think, in the event of these rooms being vacated, be brought back to the Tower, thereby saving the constant journeys which take place to and from Southampton, and a good deal of postage.

"Do you think it would be more convenient, considering the growing importance of the surveying establishment, that it should be in the metropolis, and not at Southampton?—I am not so competent to give an answer upon that as many others might be, but I think it would be preferable.

"Mr. V. Smith: Is the Map Office now at Southampton in public premises?—It was an old barrack.

"Sir J. Graham: Why was Southampton selected?—On account of having this vacant place, I believe.

"Therefore, it was not that Southampton was the most convenient place for this particular duty, but because it was the only place where accommodation could be found at the time?—Certainly.

"In your opinion, if accommodation could be found in the metropolis, for every purpose of rapid communication and central position, it would be an advantage?—I should say decidedly so.

Major-General Charles R. Fox was perfectly right. It was not for the benefit of the national survey, nor for the good of the public, that the headquarter offices were moved to Southampton. The Ordnance Survey affords a rare example of the administration of a great survey being carried on in a provincial town. The only other case of the kind that readily comes to mind is that of Italy, which has its Istituto Geografico Militare in Florence, and not in Rome. But France, Germany, Spain, Belgium, India, the United States, and hosts of other countries, have their national surveys properly housed in the national capitals. The result of having had the administrative offices fixed at Southampton during the past eighty-four years has been to give the Survey a certain extra degree of independence, at the cost of its getting

† The writer is indebted to Mr. F. J. Hudleston, of the War Office, or this reference.

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somewhat out of touch with the great offices of the Government and with the scientific and business activities of the nation. Certainly, from 1842 onwards, there comes a difference in Colby's relations with the Honourable Board; he is no longer able to go in and out in the old way, and discuss matters as they arise. No longer is he able to dine at Airy's hospitable table on Sundays, or to meet the astronomers, or engineers, or geologists, or geographers as frequently as he used to meet them in the past. But the change was not wholly for the worse. There was more room at Southampton than there ever could be in the Tower, and the various technical departments were now more free to develop. But the choice of Southampton was clearly a kind of accident, whether the Survey Officers wished to go there or not; and the ideal solution would have been to build an establishment in the outskirts of London, say at Kensington.

The history of the "old barrack" at Southampton is the following: Sometime about the end of the eighteenth century, probably, cavalry barracks were built on the ground now occupied by the Survey buildings. These barracks were, in 1816, taken over by the Duke of York's Royal Military School, then called the Royal Military Asylum. This well-known institution is a military school, founded for the training of the sons (and formerly, also, daughters) of soldiers. It was opened at Chelsea in 1803. "The Peninsula War was followed by such a great increase in the number of pupils of the School at Chelsea, that branch establishments were opened at Southampton, and one for infants at Parkhurst, Isle of Wight. . . The alterations at Southampton were commenced on the 24th June, 1816, and finished in the following year. The expense of altering a cavalry barracks to a school for children, including additions to building, and the purchase of ground, from 1816 to December 31st, 1830, amounted to £15,955 17s. 2d. The boys and girls occupied the school from 1817 to 1823, when all the boys, except the infants, were transferred to Chelsea, the girls at the latter place going to Southampton. The number of pupils at Southampton during the years 1817-1823 was 400. After the girls were transferred to Southampton their number was gradually reduced. . . . The year 1840 saw the end of our branch at Southampton."*

The open space at the foot of the Avenue, outside the Survey Office, is still known as Asylum Green, and thus perpetuates the memory of the twenty-three years of the existence of the Royal Military Asylum at Southampton. It must be repeated that the occupation of this old converted barrack school by the Survey was not due to any motives of policy, and was not approved because

* From a memorandum by Mr. Lewis C. Rudd, of the British Museum, an Old Boy of the Duke of York's School.

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SIR GEORGE AIRY, D.C.L., LL.D., F.R.S.
1801—1892.
Astronomer Royal,
1835—1881.

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Southampton was a specially suitable place for the Survey headquarters, but came about chiefly " because it was the only place where accommodation could be found at the time."

The change of headquarters put the Survey, as has been said, a little out of touch with the scientific societies and scientific men of the metropolis. Amongst those scientific men one should specially mention Airy, who took the place that Dr. Charles Hutton filled in early years, in that he was frequently consulted by the officers of the Survey and the Board of Ordnance. Airy had so much to do with the geodesy of the operations that it seems desirable to give a brief account of his work, in so far as it affected the survey.

Airy.—Airy was born in 1801, and after holding the appointments of Lucasian Professor of Mathematics, and Plumian Professor of Astronomy, at Cambridge, was, in 1835, appointed Astronomer Royal, in succession to John Pond. His influence on the Ordnance Survey was very marked. He was always accessible to Colby and to others, like Yolland, who were concerned with the scientific aspects of the work. He remained Astronomer Royal for forty-six years, that is, until 1881 ; but it was chiefly in the early part of his long tenure of that appointment that his influence was felt in the Survey. Airy's *Figure of the Earth* was adopted by the Survey shortly after 1830, when it was published in the ***Encyclopædia Metropolitana.*** As the maps of the Survey are still plotted on this figure, and as the ***Encyclopædia Metropolitana*** of 1830 is not very accessible, it is, perhaps, desirable to explain how Airy arrived at his figure.

At that date it would have been possible to use 14 arcs of meridian and four longitudinal arcs. Airy rejected the latter, no doubt wisely. As to the meridional arcs, he noted that the greatest discordances occurred when observations in mountainous countries were made use of ; it was, of course, well known in those days that mountainous masses attract the plumb-bob. He, therefore, rejected the arcs, such as the Arc of Peru, measured in mountainous regions, and he was left with eight arcs from which to derive his figure. These eight arcs were : two French arcs, the American arc (Mason and Dixon), the English arc from Dunnose to Burleigh Moor, two Indian arcs, Gauss's Hanoverian arc, and Struve's Russian Arc ; the two longest being the French arc of 12° from Formentera to Dunkirk, and Lambton's and Everest's arc of 16° measured in India. Airy refused to adopt the method of least squares, and used only the terminal latitude of each arc ; in fact, his method of calculation was arbitrary and differs widely from modern practice. The elements of Airy's figure are:—

a (semi-axis major) in international metres, 6,377,542

c the compression, or $\frac{a-b}{a}$ where b is the semi-axis minor, $\frac{1}{299.3}$

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This may be compared with Hayford's Figure, which, in 1924, was recommended by the International Union of Geodesy and Geophysics. In this Figure,

$a = 6{,}378{,}388$ international metres,

$$c = \frac{1}{297}$$

As compared with the most recent Figure, Airy's has, thus, a semi-axis major which is 846 metres too short, and it has somewhat too small a compression. But the effect of those differences on the maps of the British Isles is negligible: no practical or theoretical purpose would be served by recomputing the geographical positions on the map, and it is unlikely that any figure other than Airy's will ever be used for the Ordnance Survey of these Islands.

Mr. H. L. P. Jolly has shown that the adoption of Hayford's figure, in place of Airy's, would alter the latitude of Cape Wrath by about $3\frac{1}{2}$ seconds, and would alter the longitude of Achill Island (off the coast of Mayo) about $5\frac{1}{2}$ seconds of arc; in each case assuming Greenwich to be the origin of the computation. If the changes were made, there would be no difference in the linear accuracy of the maps, but the latitude and longitudes round the margins would be shifted slightly. It is, clearly, not worth doing.

The question may be asked, Why does the Survey require to use any figure of the earth? The answer is, that for such a small portion of the earth's surface as is covered by Great Britain, or by Ireland, a figure is not necessary for the construction of the maps themselves. The original six-inch maps of Ireland were, for instance, constructed without reference to any figure, no latitude or longitudes being marked on these sheets. The whole of Ireland could have been mapped on one meridian, and the whole of Scotland, without reference to the real shape of the earth. England, which stretches some 160 miles east and west of the central meridian of 2° W., would have required two meridians, but no accurate knowledge of the real shape of the earth would have been wanted for the large scale maps. Of course, when we come to map the British Isles as a whole, we must fix on some definite projection and have at least an approximate notion of the true shape of the earth. But the real necessity for the adoption of a figure becomes apparent when we consider that latitudes and longitudes must be shown on nautical charts of all descriptions, and that the accurate delineation of the shores of these islands on such charts is taken from the Ordnance Survey.

Airy's calculation of a figure was, then, necessary for the use of the Survey. It was by no means his only service to the Department. In the autumn of 1841 Colby consulted him as to the design of a Zenith Sector for the observation of latitudes. The instrument was to be more portable than Ramsden's, and to be of

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such a nature that good results could be got from the work even of a single night. "The Astronomer Royal, with his usual readiness to oblige, gave the subject his immediate attention, and accordingly proposed, and subsequently superintended, the construction of the instrument." It differed from Ramsden's instrument chiefly in the substitution of spirit levels for a plumb-line, and in the solidity yet portability of the few parts comprising it. It was used, between the years 1842 and 1850, for determining the latitudes of five stations in Ireland and of twenty-two in Great Britain.

Another matter, affecting the Survey, which occupied Airy, was the question of tides and the level of the sea. We have seen that in the early days of the work "the low water mark" was taken as the datum for heights. Whewell remarked, in 1838, that surveyors and naval men are in the habit of assuming the surface of *low water* to represent the level of the sea, whereas it is not even approximately a level surface at all. Whewell recommended *mean water*, "the means of low and high water." Mean water is not quite the same thing as mean sea level, but it is not very different. The latter is now universally recognised as the proper datum.

Airy also, in 1844, determined the longitude of the trigonometrical point Feaghmaan, that point on the Island of Valentia, off the south-west coast of Ireland, which is the westerly termination of the great European Arc of parallel along 52° north; this he did by the transport of chronometers from Greenwich. This longitude was re-determined by telegraph in 1862.

Airy was also much interested in pendulum determinations of the density of the earth. In 1826, and again in 1828, he carried out experiments at the bottom of Dolcoath mine in Cornwall; and again, in 1854, at the bottom of Harton Colliery, 1,260 feet below sea level, he swung pendulums for the same purpose.

But enough has been said to show how considerable was Airy's activity in scientific matters affecting the Ordnance Survey, and what a fortunate thing it was that, for a long series of years, he should have occupied, as it were, the position of official scientific adviser to Colby and his successors. Airy resigned his position as Astronomer Royal in 1881, being then eighty years old; he died in 1892. In the *Dictionary of National Biography* his son is quoted as summing up his father's scientific character in these words: "His nature was eminently practical, and his dislike of mere theoretical problems and investigations was proportionately great." No doubt he found in the work of the Survey just those practical applications of science which most attracted him.

A few letters from Airy to Colby have been preserved. Amongst them, perhaps the most interesting is the following, written in 1850, after Colby had retired. The latter had evidently been asking for Airy's views on education:—

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"About the education of your sons, I cannot help you much in regard to treatises. I never expect very much from education; I think, perhaps, not so much as you do. Taking, for instance, the general subject of mathematics, with the view to its ulterior application to the business of science that may turn up in life, it appears to me that all that can be done is this: First, to give a perfect habitual familiarity with the machinery of mathematics, for example, with the general process of algebra and with the principal properties of circles and squares, etc. Secondly, to give what may be called a mathematical drill, to enable the mind to appreciate demonstration, and to see, in many cases, towards what conclusions the premises must lead without following them completely. But as to preparing the mind (otherwise than in this general way) for more than a very small fraction of the wants that will occur, I consider it desperate. For the second of the purposes that I mention, I think the modern school of mathematics (employing differential calculus, etc., when geometrical considerations will do as well) much inferior *in general* to the geometrical school: and so, I think, do most persons who have attended carefully to the results of academical education. Pray give Mrs. Airy's remembrances and mine to Mrs. Colby and believe me, my dear sir,

Yours truly,
G. B. AIRY.

Two more letters to Colby:—

Royal Observatory, Greenwich.
1841, October 4th.

MY DEAR SIR,

To-morrow (Tuesday) between two and three will be perfectly convenient to me. I shall, therefore, expect you, Yolland and Simms, about that time: dinner will be ready between three and four, and you then will be pleased to dine with us. This order being issued by Mrs. Airy there is no escape from it. You will notify accordingly to Yolland: I am just writing to Simms.

Yours very truly,
G. B. AIRY.

1842, January 10th.

MY DEAR SIR,

I am much concerned to find that you are laid up by illness. But as it *has* come, I hope you will indulge it well. Your life has been one of most incessant activity, and I think that Nature is giving you a hint that a little quiet, especially in a severe season, is not only comfortable, but also necessary. . . . ."

Yolland.—All who have had occasion to study the geodesy of the British Isles will remember that we owe a great deal, in this connection, to Captain William Yolland. In 1842 Yolland wrote the account of the *Astronomical Observations* made with Ramsden's Zenith Sector; this account discusses the latitudes of 10 stations, determined with Ramsden's instrument, between the years 1802 and 1818, with the addition of some observations at Greenwich in 1836. In 1847 he published an admirable work on the *Measure-*

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ment of the Lough Foyle Base, a measurement which had been carried out some twenty years earlier. And in 1852 he published a bulky and elaborate report upon the *Astronomical Observations* made with Airy's Zenith Sector, at 27 stations, during the years 1842 to 1850. These three works are the standard authorities on the observations with which they deal, and are written in an admirably scientific spirit.

The writer of these books, so important in the scientific history of the Survey, was born in 1810, was commissioned as a Second-Lieutenant in the Royal Engineers in 1828, and became a Second Captain in 1843. He was posted to the Ordnance Survey in 1838, about the time that Colby left Ireland, and when the question of the six-inch Survey of Scotland was being settled. Yolland was greatly trusted by Colby, who, in 1842, placed him in charge of the operations at the headquarter offices at Southampton. Late in 1846, Colby, having made up his mind to retire, recommended Yolland as his successor. But Colby had reckoned without the Board of Ordnance; and, indeed, it does not appear that he had taken any adequate steps to pave the way and to secure the concurrence of the Board. The removal of the headquarters of the Survey from the Tower to Southampton had put Colby a little out of touch with the authorities in London, and Burgoyne's appointment as Inspector-General of Fortifications seems to have had the effect of still further hindering Colby's approach to the Master-General. Things were very different from what they had been in the twenties in that respect. However that may be, Yolland was not the senior of those serving under Colby; there were two captains senior to him, and from a military point of view it is difficult to see how the appointment could have been made. Colby had not taken early measures to ensure his being succeeded by an officer of sufficient competence and seniority. In making the recommendation he writes Sir John Burgoyne that,

"An objection may arise to the appointment of so young an officer as Captain Yolland; the continuance of peace has made promotion slow, but he is about the same age (37 years), and has about the same length of service (19 years), which I had, when I succeeded the late Major-General Mudge in charge of the Survey in 1820: and I have upwards of eight years' personal observation of his close attention to the various duties, and of the results of his management, to warrant me in proposing his name."

Apart from seniority, and assuming that Portlock was not available, Yolland was without doubt the right man. In a letter to him, dated 19th March, 1847, from Douglas Galton, there occurs this passage:—

"The high and deserved praise of the present state of the Survey makes me the more regret that the new Superintendent has been appointed. I was talking about it to Harness the other day. He says

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Matson asked him his opinion as to who should succeed Colby, and he says that it never occurred to him that any one except yourself could be named to it, that everyone who knew anything about the Survey knew that all improvements of late years had been introduced at your suggestion, and that although it is quite fair that General Colby should have praise due to those improvements, because he placed you in that situation, yet it is not fair that on his retirement a fresh person knowing nothing of the subject should be brought in to gain credit from your brains."

However, Sir John Burgoyne either would not, or could not, overcome the difficulty of Yolland's want of seniority, and a complete outsider was appointed. Yolland remained on the Survey for seven years more; but there was inevitable friction with his new chief, and in 1852 he was transferred from Southampton to the Irish Survey. In 1854 he left the Survey for good—but not for the good of the Survey—and was appointed an Inspector of Railways under the Board of Trade. In 1856 he was a member of the Commission appointed to consider the training of cadets for the scientific corps of the army. In 1859 he was elected a Fellow of the Royal Society. In 1877 he became the Chief Inspector of Railways, a post which he retained until his death in 1885.

Yolland was an able and popular officer. The testimony of men like Galton, Harness and Colby, and the good opinion held of him by Airy, are conclusive as to his ability; and as to his popularity, it is to be noted that, when he left Southampton for Ireland, in November, 1852, the Mayor and Corporation presented him with an address in acknowledgment of the interest which he had taken in the welfare of the town.*

Colby's Successor.—Sir John Burgoyne, apparently on his own initiative, and in spite of Colby's strong protest, recommended to the Board of Ordnance that Colby should be succeeded by Lieut.-Colonel L. A. Hall, R.E., and this officer became Superintendent of the Ordnance Survey, as the title then was, in April, 1847. Lt.-Col. Hall had had no previous acquaintance with survey matters. In a letter dated 16th March, 1847, Colby remarks that the official documents on the case "will show most distinctly that neither Sir John Burgoyne nor Lord Anglesey have any notion that the charge of a great national survey requires any experience of the nature of such a duty."

No doubt Hall had some good qualities which made him acceptable to the Board. His appointment was, however, something like a confession of failure on the part of the authorities, for it was known to all that he would have to rely upon Yolland. And for five-and-a-half years he did rely upon Yolland, who, in difficult circumstances, maintained the reputation of the Department, under

* *Dictionary of National Biography. Art. Yolland.*

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a chief who was a mere administrator. It was Yolland, for instance, whose evidence was sought by commissions and parliamentary committees. The experiment was not a very happy one, and was drastically terminated by the Board after a few years' trial.

Colby was furious at Hall's appointment, and by letter and in personal interviews expressed himself with much freedom to the authorities in London. But Hall remained Superintendent until a year or two after Colby's death. It is, perhaps, significant that Colby having died in October, 1852, Hall sent Yolland to Ireland the month after; no doubt the strain had become rather more than either could bear. The Survey was then left without anyone at headquarters who understood the trigonometrical or astronomical work, until young Clarke joined in 1854. This appointment of Clarke is, by the way, very much to Hall's credit, and the scientific tradition was maintained, with the slight break mentioned, until 1881.

Some Miscellaneous Letters.—From Charles Macintosh to Colby :—

Red Bull Wharf, Upper Thames St.,
15th February, 1826.

"I now send you a specimen of muslin; as I believe, in all respects properly water proofed; and capable of resisting any test. I fear the colour is too dark for doing maps upon; but think, with care, that evil may also be remedied. . . ."

From Sir George Everest, shortly to be Surveyor-General of India, to Colby :—

Oriental Club, Hanover Square,
27th June, 1829.

"I am induced by the kindness of your offer when I last had the pleasure of seeing you to take a journey to Ireland this summer to witness the working of the machinery of your beautiful system in the field. I am too late, I fear, for anything connected with the base line measurement, but there will still be a great deal to interest me, I feel persuaded. . ."

From the same, dated November 23rd, 1829, describing two sections of the Indian arc, and ending :—

"Now I want your similar data to compare with. Give me all you have and all my data are at your service. . . P.S. The Court of Directors have made me Surveyor-General of India—tell this to Robert Boyd."

From the Secretary to the Birmingham and London Rail Road Company to the Board of Ordnance, 69, Cornhill, 23rd May, 1831 :—

"The Company formed for the purpose of establishing a railroad communication between London and Birmingham, to which I am Secretary, have derived so much benefit from the published Ordnance Surveys in the course of the examination which they are making of the intermediate country, that I am anxious to obtain for our Surveyors the additional advantage of access to the documents which are not before the public."

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From Henry Raper, author of the celebrated treatise on *The Practice of Navigation*, to Colby, 12, Milton Street, Dorset Square, April 29th, 1839 :—

"MY DEAR SIR,

"I take the liberty of enclosing you a prospectus or two of a work which is now printing, and on which I think I have mentioned to you I have been for some time employed.

"The prospectus contains an account of the first volume, which I call *practice*, in order that the public may not feel themselves obliged to buy two volumes when one contains all that they want. I need not trouble you with further remarks on the first volume or part, than to observe that I have omitted Surveying altogether as not belonging to the place of the spectator on the surface of the earth; besides which, it is trifling both with the reader and the subject to pretend that surveying is to be learnt in three pages and a half. . . .

"I would not have occupied your time with these details, but that as your opinion will be of great consequence to the character of my work, I am anxious that you should be prepared to expect not merely a *technical* but an *educational* object in the composition; for I cannot but think that the only way to promote precision and clearness of ideas in our merely practical men is to place before them the matters they have to deal with, already digested with every attention to unity and purity of design, and the utmost distinctness of arrangement, and further, that this precision of ideas is more likely to become, insensibly, a habit, than to be inculcated by any precepts.

"The plan that I have adhered to involves the principle that practice should come *before* theory, as it appears to me rather inconsequent that a man should learn theory first—for the word theory implies specific knowledge of an end or fact which theory is to explain. In fact, if for 'stargazing' you read 'walking' the absurdity of saying 'study the doctrine of equilibrium in order to be able to walk,' becomes absurd enough. . . .

Believe me,
My dear Sir,
Yours very sincerely,
H. RAPER.

Raper's *Practice of Navigation* was published in 1840, and he was awarded a gold medal by the Royal Geographical Society for this work. The projected second volume on "Theory" was never published.

From Colby to Captain Henry James (afterwards Director of the Ordnance Survey), 7th May, 1845 :—

"When I undertook to direct the Survey of Ireland I considered that it was the first essential measure for the pacification and improvement of the country, and I gave very strict orders to prevent any political or sectarian interference in the survey duty. The selection of the persons to be employed was solely guided by their supposed fitness for the work they were to do, and their advancement or removal depended upon their fitness or unfitness for their work, as proven by trial. I never allowed any enquiry as to their religious creeds, or for whom or against

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whom they had voted at any election. But I certainly did prohibit those employed from attending political meetings, to prevent, as far as my influence would go, any party politics from continuing to disturb the peace of the country. I believe that these instructions are pretty generally known in Ireland, and I have not been aware that Captain Larcom has deviated from them. . ."

The following remarks, which are in Colby's handwriting, seem to be part of the draft of a farewell order :—

. . . " After the decease of my much esteemed predecessor, the late Major-General Mudge, the Duke of Wellington did me the honour of placing the Ordnance Survey under my direction.

" And when the House of Commons ordered a Survey of Ireland on a scale of six inches to one mile, as the basis for a new valuation of the land in that country, His Grace also confided to me the direction of that Survey. The entire Survey of a large country, with the minutiæ of detail and accuracy required for a valuation of land, had no precedent of any similar work to guide its arrangements. I, therefore, devised new methods which I proposed for His Grace's sanction. I had learned from Major-General Sir Charles Pasley, the skill and intelligence which the Royal Sappers and Miners evinced in the acquirement of his course of instruction. And I proposed a military system with officers of Royal Engineers, soldiers of Royal Sappers and Miners, and assistants. From His Grace the Duke of Wellington, his Secretary, the Lord FitzRoy Somerset, and Viscount Hardinge, then Clerk of the Ordnance, I obtained every requisite authority and much valuable aid. It is, therefore, highly gratifying to my feelings to have an opportunity of expressing my gratitude for their early aid in enabling me to produce the present prosperous state of the Survey."

Let us, then, glance at the state of the Survey during Colby's last year of office.

The State of the Survey in 1846.—In 1846 the Survey was almost exactly one thousand strong, including all officials, both in Great Britain and in Ireland. The strength of the Survey of Ireland had come down with a run after 1840, when there were nearly 2,000 men employed in that country. The reason for this was that the original six-inch survey was approaching completion; the field work was finished in 1844 and all the maps were engraved by 1846. Only a small staff of about 250 men was left, after that year, to carry on the revision.

The original six-inch Survey of Ireland had taken rather more than 20 years to execute, and had cost about £800,000.

It should be noted that, in 1851, Captain William Yolland gave evidence before the Select Committee on the Ordnance Survey of Scotland, that the six-inch survey of that country " could be done in 15 years at a cost of about £750,000," including the contouring.

In January, 1846, there were 735 persons employed upon the Ordnance Survey in Great Britain and 132 of this total were

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stationed at Southampton. The offices of the detail survey were at Dumfries, Liverpool, Preston, Wakefield and York. The main work was the original six-inch survey; this was published in "full" sheets, each 36 inches from east to west, and 24 inches from north to south. The sheets were engraved on copper. Work was going on chiefly in Kirkcudbrightshire, Lancashire and Yorkshire.

There was that innovation, a contouring department, thirty-five strong, and this was occupied in contouring Lancashire. Great attention was paid to the correct delineation of county and other administrative boundaries.

There were also the "5 Feet" plans in hand, that is, plans on a scale of 1:1056; and a few one-inch sheets were being engraved. But the main energies of the Survey were directed to the revision of the six-inch map of Ireland, and the execution of the original six-inch maps of Scotland and of the northern counties of England.

Colonel William Yolland gave evidence before the Registration and Conveyancing Commission to the following effect: "The orders under which the Survey proceeds at present contemplate the completion of the six northern counties of England and the whole of Scotland on the six-inch scale, with maps of the towns on the 60-inch scale, this part of the country not having been previously surveyed." . . . "When I say 'towns,' I mean towns having a population exceeding 4,000 inhabitants."

In studying the reports and returns of these years, one gets the impression of a carefully organized department, carrying out its duties methodically, by means of a well-considered system of division of labour, controlled by an efficient headquarter office. In fact, Colby's large-scale map-making machine was working well.

The End of the First Hundred Years.—Colby's machine was working well, and in that state we will take leave of it, when, in March, 1847, he retired from the Army and the Survey. The machine was working so well that it underwent but little change for a generation, or more, to come. We have attempted to trace, for the first hundred years, the growth of this survey, the finest of all national surveys in its completeness and usefulness. And we will end with the picture of old Roy, in his house in Argyll Street, urging in his last paper, written just before he died in July, 1790, that the trigonometrical operation so successfully begun should be extended over the whole country; and, as we may suppose, casting his thoughts back to his share in those early explorations of the Highlands, which were to lead at last, though not in his lifetime, to the creation of the Ordnance Survey.

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SOME NOTES ON FRENCH ARMY TRAINING.

By LIEUTENANT H. B. HARRISON, R.E.

WHILE most officers will be fairly familiar with the salient features of the French Army training, yet it is probable that the details of the life and training in peace time of the officers, N.C.O.'s and men are not quite so well known.

The following few brief notes may be of general interest. They were collected during a two months' attachment to a French infantry battalion, followed by one month with a sapper regiment. The battalion in question was the 6e bataillon (Alpin) de Chasseurs à Pied, stationed at Grenoble, while the sapper regiment, also at Grenoble, was the 4e Regiment du Génie, a regiment of sappers and miners.

The Chasseurs à Pied may be said to be the élite of the French infantry and are organised in 31 battalions spread out along the N.E. and E. frontiers, which they hold in an emergency pending the mobilization of the field armies. Those battalions stationed opposite the Italian frontier at such places as Grenoble, Barcelonette, and Nice, are called " alpin," for obvious reasons, and enlist a very hardy type of hillman not unlike the Gurkha in build.

The following notes on the Officers cover generally all branches of the Army :—

OFFICERS.

With national service there are, of course, two distinct types :— 1, Regular (*officier actif*), 2, Reserve (*officier de réserve*).

1. *The Regular Officer.*—A regular commission can be obtained in three ways :—

(*a*) By direct entry into the Army through either St. Cyr or l'Ecole Polytechnique. In each case there is a competitive examination followed by a residence of two years. The two schools correspond approximately to our Sandhurst and Woolwich respectively, although l'Ecole Polytechnique is not essentially a military establishment, a large number of the students, on passing out, entering civil life as engineers.

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(*b*) Through the ranks. A young man wishing for a commission by this means writes to the nearest *Bureau de Recruitement* to be enlisted in the regiment of his choice. He is sent to that regiment as a private, and on arrival is put into a special platoon kept for the purpose in every regiment. After four months, with good conduct, he is made a "caporal," which is a stage between private and N.C.O., and now enters the special platoon for budding N.C.O.'s. After a further five months, with good conduct, he becomes a sergeant and is now an N.C.O. Having served two years as a sergeant, he can take a competitive examination for entrance into whichever of the following schools he may choose :—

St. Maixent, for infantry and tanks.
Fontainebleau, for artillery.
Vincennes, for administrative services.
Versailles, for engineers.

He does a year at one of these schools and, after a passing-out examination, leaves as a 2nd lieutenant, becoming a lieutenant after two years' service.

(*c*) Only a few officers receive their commission by the third means, which is direct promotion from the rank of "adjutant" to that of 2nd lieutenant, after at least 15 years' service. The "adjutant" corresponds approximately to our warrant officer, and there is one per infantry company.

There are no promotion examinations for French officers corresponding to those we have in England.

To pass from the rank of lieutenant to captain and to each successive grade up to General, every officer has to attend for a three months' course at a special school at Versailles. An officer attends when nominated to do so by the French War Office, which is guided by the length of service and by the biennial confidential reports of each officer.

Thus, although the normal service for a captaincy is about 12 years, by being specially recommended by his Commanding Officer for accelerated promotion, it is quite common for a lieutenant to attend his three months' course at Versailles after, say, seven or eight years' service. The same applies from captain to major and so on.

2. *The Reserve Officer.*—He does the usual 18 months' compulsory service at the age of 20.

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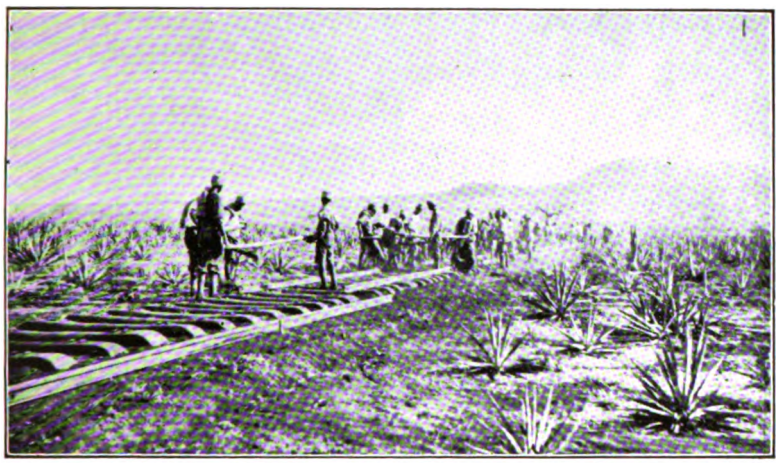
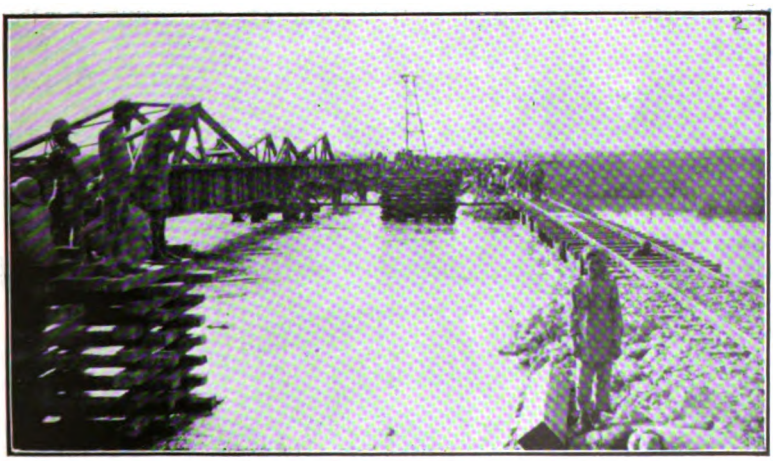
NOTES ON MILITARY RAILWAYS.



No. 1. Starting Voi-Kahi-Moschi Railway from Voi.



No. 2. Ruvu River, East Africa.

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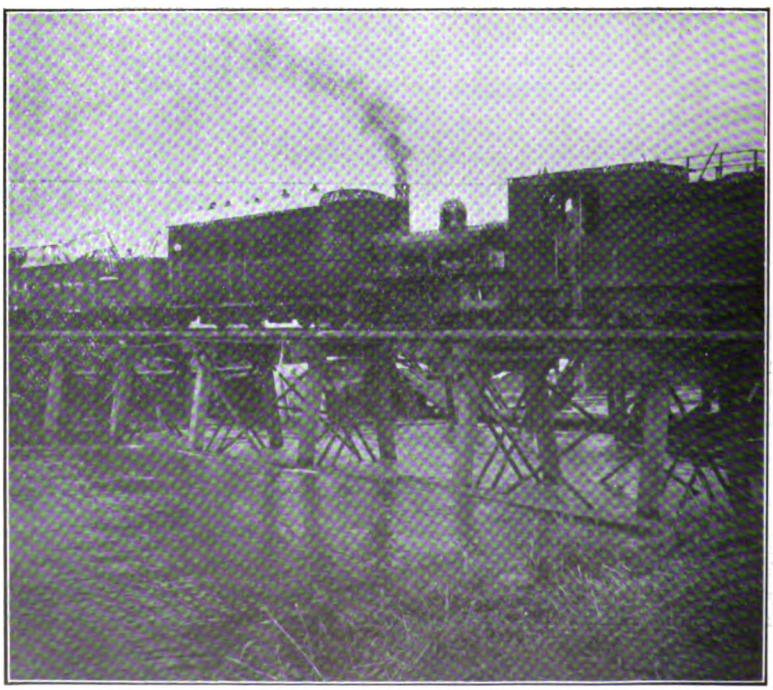
No. 3.



No. 5. 2nd Pangani Bridge.

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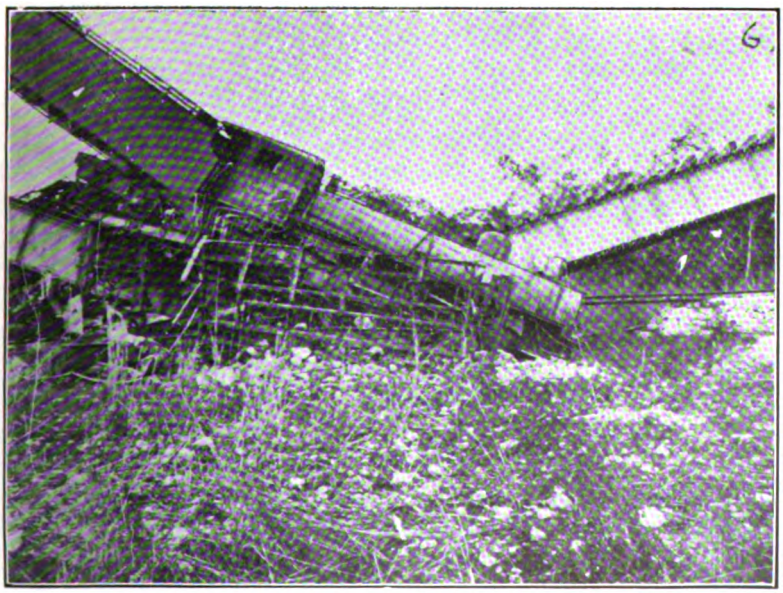
No. 4. Temporary trestle Bridge built by Indian Sappers across Pagani River, East Africa.



No. 6. Showing engine, tender and trucks heaped up on destroyed bridge.

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Trestles should be of as simple design as possible, and without the let-in joints so dear to the carpenter. It is sufficient to saw and adze the capsill and groundsill only so much as will give the raking struts a bearing normal to their thrust. Anything further wastes time. Again, if the vertical and raking struts (or legs) of the trestles are properly triangulated, no diagonal bracing is required with trestles up to twenty feet high. Another fruitful source of wasted time is meticulous levelling up of the trestle. A properly triangulated trestle can tilt sideways a foot out of the vertical if the necessary correction is given by a packing piece on the capsill (Figs. 3 and 5).

Provided that the groundsill can be kept in place by stakes on each side, longitudinal bracing between trestles is not required, it being understood, of course, that the heads of the trestles are secured in a vertical position, as seen from the side, by rigid attachment to the girders. Not only is it not required, but it may even be a source of danger. For instance, if a trestle wants to sink at all, the bracing cannot stop it, and is bound either to split itself or the member of the trestle to which it is secured. In addition any heavy object floating down stream is liable to strike it and imperil the bridge, as the writer once experienced when a hippopotamus got mixed up with some longitudinal bracing (Fig. 4).

This view received further support from the standard design of bridge piers in Tanganyika Territory, where the line from Dar-es-Salaam crosses low-lying land liable to floods. These piers were built on a pile foundation, and provided with a knuckle joint a few feet above ground, so that if their tops had not been pinned to the overlying girders, they would have all fallen down like ninepins. The girders, being fixed to their abutments, kept the top of the piers in their proper position, while the bottoms were free to accommodate themselves to any settlement which might take place. One bridge of this design consisted of seven or eight spans of 30-ft. Provided, then, that the girders are adequately fixed to the top of ordinary wooden trestles, the principle of omitting longitudinal bracing seems to be justified in practice, and no doubt saves time. (It may be objected that braking stresses necessitate longitudinal bracing, but in practice such stresses are transmitted through the girders to the abutments, *e.g.*, on the Khyber Railway.)

Ordinary 12-in. dogs will hold a trestle together when it is once in position, but it is advisable to strengthen it by a Spanish windlass while launching and add drift bolts when any degree of permanency is aimed at.

Crib piers are most easily made by drilling a one-inch hole near the ends of ordinary sleepers and threading them on to ½-in. steel rods, so as to form a square cage which can be weighted with boulders. The chief point to make sure of is that the weight of

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girders comes upon the corners of the crib and not upon one unsupported sleeper. Single cribs can be used up to about 10-ft. and double cribs to 20-ft. In the South African War, crib piers were made, three sleepers wide, over 34-ft. high, but a great deal depends upon the sleepers being uniform. Cribs more than one sleeper wide should be bonded together every five feet or so by having transverse rails built into them.

The strength of girders can readily be calculated from the formula.

$$\text{Total stress in either flange} = \frac{\text{Distributed load}}{8 \times \text{depth}} \times \text{Span.}$$

the units of stress and load being the same; and those of span and depth. This applies whether the girders are rolled steel or built up out of plates. All that is necessary is to convert to a partially concentrated load, measure up the square inches in the flange, and see that the stress divided by the square inches does not exceed an agreed number of tons between six and eight, according to the views of the particular Chief Engineer. No bridge is known to have failed when working to the Board of Trade rule of 6 tons per square inch, without any allowance for impact. (This is the same as allowing 8 tons per square inch with a 33 per cent. factor for impact.)

Plate girders are almost impervious to ill-usage. Fig. 6 shows a two-span bridge of fifty-feet girders, whose central pier was destroyed with an 80-ton engine and tender stationary over it. The whole dropped some 18-ft., and everything combustible was burnt. No damage whatever was sustained by the girders (which were raised on to a timber trestle pier very quickly) and they are probably in use to this day.

When timber railbearers are used in place of girders, their safe distributed load can be calculated for each inch of width from the formula—

$$\text{Load} = \frac{\text{Depth squared (inches)}}{13 \times \text{Span (ft.)}} \text{ tons.}$$

The load thus given must be multiplied by the number of inches which the beam is wide.

The safe load on timber struts can be taken straight from the tables in Molesworth's or any standard pocket book, but it is convenient to remember that, with 12-in.×12in. timber, if the load in tons and the length in feet do not add up to more than 65, the load will not exceed the figure permitted by various formulæ.

The simplest form of girder bridge which will generally be used on military railways are "deck spans." In these the sleepers rest on the top of the girders, being fixed rigidly thereto by hook bolts, and the rails spiked as usual to them. Sleepers on deck spans should be placed so near together that if a wheel or coach

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becomes derailed it can run along on the top of them, instead of dropping between.

Girders need not be elaborately cross-braced on military lines. It will usually suffice for spans up to 30-ft. if three spacing timbers are cut to fit in between the webs, and the whole bolted together with a couple of tie-rods at each timber.

A very useful substitute for girders can be made by laying rails in their stead. A simple rule is to lay one rail for each foot of span. For instance, over a 12-ft. span six rails under each running rail would be wanted. Spans up to 18-ft. can be bridged in this way, but beyond this deflection becomes excessive. Photos 4 and 5 show two such bridges, in which the spans were 16-ft. It is assumed in the above rough rule that the weight of the rail per yard is not less than five lbs. for every ton of axle-load.

Construction or repair trains can be passed over ordinary track unsupported by sleepers or culvert, up to eight feet; a very useful fact to remember when a series of small culverts has to be made or repaired. A repetition of such traffic would, of course, bend or cripple the rail. Another interesting example of what trains will do was given in East Africa, when a whole train travelled safely over a gap of 2-ft. blown in one rail by the enemy.

GRADIENTS.

These should be kept as easy as the country will allow, but even with permanent railways steep gradients may be necessary, as with one recently constructed in India, where the line could not be got through with a flatter grade than 1 in 25.

It may sometimes be possible to make the grade in the forward direction easier than those against the return journey. Opinion is divided as to the advisability of this, but it seems to have obvious advantages for a military line, where the heaviest loads are going to the front for consumption there, and most of the return traffic will be empties. Steeper gradients than the above have been successfully worked on civil lines, such, for instance, as the 1 in 22½ over the Rockies in British Columbia; but this has since been reduced by a spiral tunnel through the mountain, on the Swiss model, to 1 in 45. During the war, one of the camp railways in England had a gradient of 1 in 16, but such gradients, if of any length, need frequent runaway sidings, and are a standing source of danger and anxiety to the operating staff.

When gradients have to be put in on a curved portion of the line, it is necessary to reduce them so that the total resistance to the passage of the train shall not exceed that due to the maximum grade. A simple factor of reduction is .04 per cent. for each degree of curvature. For instance, if the ruling grade is 1 in 40, or 2½

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per cent., and the curve one of 10 degrees, the compensated gradient would be 2.1 per cent., or 1 in 47.6.

Backshunts sometimes form an escape from difficulties with gradients, since by their means it is possible to zig-zag up the side of a hill, as with a road. They should, however, be avoided whenever possible, since they cannot fail to be a cause of delay, and are troublesome to negotiate at night. Visitors to India will be familiar with the reversing stations up the Western Ghats, which, however, did not prevent the ruling gradient being 1 in 37. (Within the last 10 years fresh examination of the possibilities has resulted in the reversing stations being cut out, and a much flatter ruling grade being introduced).

Curves.

Curves can be set out either with ranging rods by offsets, or with a theodolite; and are designated by their radius in feet, or the angle subtended at the centre by a 100-ft. chord. The radius method of designation has certain advantages in the matter of working out formulæ, but the degree nomenclature is almost universally used, except in England (where most of the railways had already been built before it was thought of), and is incomparably better for work with a theodolite.

The offset method of laying out a curve consists in setting off from the straight line and at right angles to it a distance calculated from the formula—

$$\text{Offset} = \frac{(\text{Length of chord})^2}{2 \times \text{Radius of curve}}$$

E.g., on a curve of 1,000-ft. radius the offset 100-ft. from the tangent point of the curve would be 5-ft. This is called the "tangential offset," and fixes the first 100-ft. chord. The next point 100-ft. along the curve is found by producing this chord for 100-ft., and laying off twice the tangential offset. And so on, until the curve reaches the next straight, or "tangent," when the tangential offset for any distance less than 100-ft. will have to be calculated as above.

The disadvantage of setting out curves by this method is that any error is accentuated as the curve proceeds, but it will almost always be employed in military lines, owing to its simplicity, and the absence of instrumental work. It is not so accurate, but quicker than work with a theodolite, which involves logarithmic calculations, unless complete tables giving the length of tangents to the curve, etc., are available.

If a curve is already laid and it is desired to know its radius, the simplest way is to find the midordinate in inches of a chord 61ft. 9½-in. long. This will give the degrees subtending a 100-ft chord at the centre, or "Degree of curve," and the radius can be

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calculated by dividing this into the figure 5,730, which is approximately the radius of a "one degree curve." *E.g.*, if the midordinate is 10in., the curve will be one of 10 degrees, and its radius 573ft. The accuracy of this method falls off as the sharpness of the curve increases, but it is accurate enough for all practical purposes.

It is not here proposed to describe the laying out of curves with a theodolite, since this method will seldom be used in purely military railways.

PERMANENT WAY.

It is sometimes thought that rails provided for military lines can be of any odd sections which can be picked up cheaply, but this is a thoroughly bad view. It involves a vast waste of time in sorting out the various sections, points and crossings, etc., before linking begins, and particularly when portions of line destroyed by enemy action have to be made good. Special fishplates have to be forged, to bring the tables of the rails level, and any initial saving in cost is quickly dissipated by the subsequent cost of overcoming these drawbacks.

The gauge will usually be fixed either by that of existing lines in the vicinity, or by the rolling stock which can be obtained from other countries. When there is any choice, the metre gauge is possibly the most suitable for military purposes, since high speeds are not required, and the narrower the gauge the sharper are the curves which can be laid. Further, the narrower the gauge, the greater is the proportion of load to the tare weight of vehicles, and the rails can, therefore, be lighter for a given duty. An average metre gauge line would probably not cost more than four-fifths of a broad gauge, and would carry much the same loads. Another advantage is that the line can be constructed more rapidly as the sleepers can each be carried by one man instead of generally wanting two apiece.

Flat-footed rails are sure to be used on military lines, since the use of the bull-headed variety would add fifty tons or more of useless weight per mile. The weight of rails (tons) for a mile of track can be found by multiplying the weight of the rail per yard (in pounds) by the factor 11/7; and the cross-sectional area, in inches, of a rail is one-tenth of its weight per yard in pounds (approximately).

Rails are generally laid with their joints square in this country but in others, *e.g.*, the U.S.A., they are "staggered," so that the joint of one rail is opposite the centre of the other one. This practice minimises the drop at joints, and makes for quieter running but, unless the line is very well maintained, is apt to set up dangerous oscillation at high speeds if the rock of the vehicle coincides with the alternate joints.

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No form of fishplating can eliminate this drop at the joints, or if the top of a rail is nicked to represent a joint, the same " drop " will quickly develop as at a real joint. On military railways it is not often possible to pay much attention to the position of joints but it is a good thing to have them square on long straight portions, particularly if sidings are likely to be required along it.

Rails should be laid with a cant inwards of about 1 in 20, to correspond with the coned tread of the wheels. The object of this is to make gravity help in keeping the vehicles central with the track, and not throw all the work on the flanges. The larger diameter of the wheel near the flange, as compared with the outer edge, tends also to compensate round curves for the greater distance the outer wheel has to travel.

This cant is given by the shape of the chair with bull-headed rails. In the case of flat-footed rails, it can be given by adzing the sleepers, or by inclining the bed of the bearing plate or steel sleeper on which the rail rests. It may be omitted altogether, if time is short, but the track will be harder to maintain, particularly at points, and the wear on tyres be enormously increased. On the N.W.R. of India, sleepers are adzed and bored at the Dhilwan creosoting works on specially designed machines.

Joints should be given a small gap of about a quarter of an inch between the rails, but at the hottest part of the day less may be allowed for expansion. The men fixing the fishplates should be given the necessary distance pieces to make sure this precaution is not omitted, or the line will be twisted about if much expansion takes place. Fishbolts should not be pulled up tighter than will allow of the rails moving between the plates to take up contraction and expansion. A pull with one hand on an 18-in. spanner gives about the correct pressure. When the line is likely to be permanent the ends of the rails and the insides of the fishplates should be well smeared with a mixture of tar and oil (half and half) and this should be done regularly once a year in the spring, when maximum expansion will occur. When the joint has been made, the outside of the plates, bolts and nuts should also be treated with the mixture to prevent them from rusting.

Sleepers must be laid with the heart side downwards to facilitate drying, and when one spike only is used on each side of the rail, the inner pair should be on the same side of the sleeper's centre line, and the outer ones on the other. This helps to keep the sleeper square to the track. Sleepers should be properly spaced, and those at the joints within a foot of each other, if the fishplates will allow of their being so close.

The secret of rapid linking, provided that the supply of material is adequate, is to have all the fishbolts run down beforehand, and to leave as much work as possible to be done after the passage of

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the construction train. The latter can be passed over the track, if the rails are merely laid on the sleepers, and kept to gauge by steel ties shaped to grip the foot of the rails—three per 30-in. rail length on the straight, five round curves.

POINTS AND CROSSINGS.

Sidings have to be provided for traffic purposes every four miles or so, and at other places as required for store depots, gun sidings, etc.

It should be the aim of suppliers of material so to design their turnouts, that they fit into a given number of rail lengths without cutting. Apart, however, from engineering contractors, this point seems to be entirely overlooked on English railways, though it was well understood by the suppliers of rails to the late enemy territories in East Africa. (In fact, the line from Dar-es-Salaam to Lake Tanganyika, built to the metre gauge, was one of the best found which the writer has seen, and was ballasted throughout with two cubic metres of 2-in. granite per running metre.)

Crossings are known by their "number," *i.e.*, 1 in 6, 7, 8, 10, etc., as the case may be. The simplest way to recognise them is to measure the distance in feet between the two places on each side of the crossing where the running edges of the rails are six inches apart. This distance gives the correct number.

No difficulty should be experienced in putting in crossings if a few simple rules are observed. One is that the distance between the heel of the switch and the nose of the crossing bears a constant relation to the number of the crossing. On the 4-ft. 8½-in. gauge the distance is found by multiplying the "number" by 6.7. *E.g.*, the distance required, or "lead," for a 1 in 10 crossing is 67-ft. Approximate factors for other gauges are: 5ft. 6-in., 8¼; 3ft. 6in., 4.9; metre, 4.6; 2ft. 6in., 3½. These factors give results sufficiently accurate for all practical purposes, whether the turnout is from a straight or curved line.

The second rule of thumb is that when the turnout takes off from a straight line, the midordinate of the "lead" is virtually constant for all numbers of crossing on the same gauge. With the 4-ft. 8½-in. gauge this midordinate is about 7in., and the radius of the curve to the crossing can be found from the formula—

$$R = 2 \times \text{Gauge} \times \text{"Number" squared plus } 1\tfrac{1}{2} \times \text{Gauge}.$$

When turnouts leave a curved line, the midordinates of the two leads will add up to about 7in. if the curves are of contrary flexure, and will subtract to 7in., if they are of similar flexure.

Midordinates to any curve of length L can be found from the formula—

$$\text{Midord.} = \frac{3L^2}{2R} \text{ inches, or } \frac{L^2}{8R} \text{ feet.}$$

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This formula is also useful for finding the amount to bend a rail of given length for laying in a given curve.

Usually the number of crossings is standardised for the particular line, but it may sometimes be necessary to put in special ones, as, for instance, when a siding has to be constructed into or between existing buildings. In this case the curve of the siding must first be determined, either with a theodolite, or by trial and error with ranging rods, and the number of the crossing found from the formula

$$\text{Number of crossing} = \sqrt{\text{Radius}} \times \sqrt{1/2 \text{ gauge.}}$$

When turnouts leave a curved line the number of crossings wanted is found from the following formulæ :—

Curves of similar flexure

$$\text{Number} = \sqrt{Rr/(R-r)} \times \sqrt{1/2 \text{ Gauge.}}$$

Curves of contrary flexure

$$\text{Number} = \sqrt{Rr/(R+r)} \times \sqrt{1/2 \text{ Gauge}}$$

The value of $\sqrt{1/2\,G}$ for different gauges is as follows :—5ft. 6in., .3 ; 4ft. 8½in., .326 ; 3ft. 6in., .378 ; metre, .39 ; 3ft., .41 ; 2ft. 6in., .44.

Points or switch rails vary in length with the gauge. On the 4ft. 8½in. they are about 1½ times the number of the crossing. At the heel of the switch the distance from the stock rail should not be more than 2in., and the longer the switch the less will be the violence of changing direction. The same applies to the number of the crossing, and the higher the number the faster can a train take the siding.

Crossings are sometimes said to be right or left handed. This means that the rail from which the nose is planed will lie in the main line, and the shorter rail spliced into it will lie in the siding, if it is laid as the makers intended. In practice, however, the same crossing will do for a siding on either side of the main.

Check rails to crossings should have a clearance of 1¾" on the 4 ft. 8½ in. gauge.

The passage of trains round curves is assisted if the gauge is slightly widened, and various formulæ exist, based on the rigid wheel base of the vehicles, to calculate the amount. Most railways have their own rules on the subject, governed by the degree of curvature, but on a military line this widening will generally look after itself, even if the outer edge of the outer rail is double spiked, as it should be.

The superelevation of the outer rail is a more important matter and here again numerous formulæ exist. The simplest method of arriving at a figure, however, is to measure the versine of a chord of predetermined length (according to gauge and maximum speed anticipated) and to give the same number of inches elevation to the outer rail. The lengths of chord generally chosen are equal

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to 1.6 times the maximum speed for the 4ft. 8½in. gauge, and 1.3 for the metre. *E.g.*, if the maximum speed on the broad gauge were fixed at 40 m.p.h., the versine of a chord 64-ft. long would give the required superelevation in inches, up to a fixed maximum.

BALLAST.

This fulfils several purposes, the chief one possibly being to distribute the load on each sleeper over a greater area of the formation than the sleeper alone would cover, and so reduce the number of sleepers required to support train loads. Other purposes are to keep the underside of the sleepers from becoming waterlogged, and by biting into them to keep them in true position. With regard to military lines, the necessity for ballast depends upon several things. The length of time the line will be required, the nature of the soil, whether soft, sandy, gravelly, etc., and the average rainfall, all play their part. If the line is of such a length that troops will want to sleep during a journey, the line must obviously be better laid than for short day trips, particularly in open country where an absence of overbridges allows the roofs of coaches to be used as extra sleeping accommodation. When ballast is unobtainable, having regard to all the circumstances of the case, the difficulty can generally be got over by putting in extra sleepers.

The amount of ballast required depends upon the permanence of the line, the amount and speed of the traffic, etc., but it is not of much use putting less than a cubic yard per running yard of line. Two cubic yards per running yard is the average when fast traffic is expected, as on main lines.

The joints are usually packed first, then the intermediate sleepers; and traffic is admitted at reduced speed until the bed has consolidated. When subsequent lifting and packing has to be done, the modern practice is to open out one side only of the sleepers, lift the low places by levers or jacks and spread a small quantity of ¼-in. chippings underneath. This method leaves the old consolidated bed undisturbed, so that the subsidence caused by the passage of the first few trains is less than it used to be when the old method of using beaters was employed. The platelaying gangs get to know very accurately how much small ballast to put underneath the low sleepers, and the net result is a better road kept in condition with a minimum of work. Platelayers who have given the new method a fair trial do not go back to the old use of beaters.

GENERAL ORGANIZATION.

As regards the general organization of military railway construction, a definite daily mileage should be aimed at. Assuming a daily task of two miles, the survey party should be able to peg

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out two miles a day; the earthwork progress at a like pace; the port of disembarkation be able to unship the necessary material, and see that it is complete in all respects; it should arrive at site in the order in which wanted; and, finally, the linking, lifting and packing gangs must be at full strength.

Since unforeseen delays are bound to occur, the more the survey and material are ahead of schedule, the greater chance is there of the line progressing according to plan.

Far greater lengths of line than two miles have been laid in one day without track-laying machinery. Nearly seven miles were laid in the Kano railway by Capt. (now Brig.-General) H. O. Mance; over five miles were laid by the South Africans during their advance into S.W. Africa; and the Sappers and Miners did four miles in one day in East Africa. These speeds, however, cannot be maintained, and the organization gets "out of breath," with the result that the daily average loses rather than gains. A film recently exhibited, "The Iron Horse," claims that the maximum day's linking achieved from one railhead during the completion of the American Transcontinental line in 1864 was no less than ten miles. For peace work a mile a day without track-laying machines is good average going, and then only when, as in the above cases, no bridges have to be erected.

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CO-OPERATION BETWEEN DIVISIONAL ENGINEERS AND THE R.A.F.

By BREVET-MAJOR R. H. DEWING, D.S.O., M.C., R.E.

Co-operation is a good horse, and for that reason it ought not to be over-ridden, but the information to be found in our official books about how the sapper and the airman can mutually help one another is so meagre that it is hardly enough to keep the animal exercised.

Engineer Training, 1922, recognises that "all ranks of engineers must understand the methods employed by aircraft," but practically its only other reference to the air is in connection with the selection of a site for a river crossing, à propos of which the value of air photos is pointed out, and air reconnaissance by engineer officers when circumstances permit is advocated.

F.S.R. Vol. I. gives a little more information. "The preparation of the surface of aerodromes and the provision of aeroplane hangars is the duty of the R.A.F., but labour and material for the same may be demanded from military sources. All buildings, hutments and works are provided by the D. of W."

It is all very well to call the preparation of aerodromes the "duty" of the R.A.F.; it certainly sounds like being the work of the Army.

It seems doubtful whether these few sentences are enough to give a sapper officer much idea of the work which may be required of him in war by the R.A.F., or of the ways in which the work of aircraft may in turn help him, and this seems sufficient justification for trying to see how co-operation between the two arms is likely to be of value.

In its peace organisation the R.A.F. has a "Works and Buildings Department," which carries out barrack construction and all the engineer services required for barracks and aerodromes. The personnel of this department has a civilian status, and though it is anticipated that on the outbreak of war the men will be enlisted for service overseas, their work will be confined to the base and L. of C. areas. In the forward areas there will be only the R.A.F. squadrons and the "Tent Detachments." The former can erect their own light portable hangars, and the latter erect large collapsible hangars of the Bessoneau type. All other engineer work required by the R.A.F. in forward areas will have to be carried out by the Army.

The only R.A.F. units with which divisional engineers will normally be concerned are the Army Co-operation squadrons, which are non-divisional units though they are usually provided on the basis of one squadron per division.

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Aerodromes must be kept beyond the reach of the bulk of the hostile artillery, and consequently, whether an A.C. squadron happens to be temporarily allotted for work with a division, or whether it is retained under corps control, its aerodrome will usually be well back towards the rear of a corps area. Under these circumstances an advanced landing ground within easy reach of divisional headquarters will usually be wanted, where machines can land to enable pilots to report personally to the division, and where, if necessary, a few machines may temporarily be kept ready for special work at short notice.

Engineer work will be required both at the squadron aerodrome and at the advanced landing ground, and, though it is the latter which more directly concerns the divisional engineers, it is not unlikely that work at the former may sometimes have to be carried out by a divisional field company; it will, therefore, be as well to consider the probable requirements at both places.

The detail of the requirements will vary with the degree of mobility of the operations, the nature of the country and the type of fighting which is going on. In both cases the preparation of the actual landing ground will be the chief item; and closely connected with this is the improvement of air approaches to the ground. A level field may be useless as a landing ground until the felling of a few trees has converted it into a passable one.

At the squadron aerodrome, roads giving access to it, water supply, hutting, splinter-proof and gas-proof shelters, storage for petrol, bombs and ammunition, and camouflage are suggested as other engineer work which might be required.

At the advanced landing ground these elaborations would probably not be necessary, and beyond the preparation of the ground itself and the provision of a track by which a car could run from the landing ground to divisional headquarters, little would be required.

Work which the R.A.F. might request the division to do for them would be arranged in just the same way as work required by the artillery or infantry formations. The General Staff, in consultation with the C.R.E., would decide upon its priority in relation to other engineer work on hand, and upon the unit or formation to be responsible for finding the necessary labour. The C.R.E. would supervise the work, detail any R.E. parties required and provide R.E. stores.

The selection of an advanced landing ground will be made by an R.A.F. officer of the A.C. squadron, but it is important that any engineer work involved should receive its share of consideration, and, therefore, an R.E. officer should accompany the R.A.F. officer reconnoitring the ground. As the preliminary reconnaissance may often be made from the air, to be confirmed by a hurried ground

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reconnaissance carried out by car from the squadron aerodrome, it is important that the C.R.E. should be in close touch with the Squadron Leader.

R.E. officers should know what is required at an advanced landing ground, both to enable them to assist in the reconnaissance and in order that they may cultivate an "eye" for likely ground and thereby be able to help the R.A.F. in their search.

In order to land, an aeroplane flies into the wind, and since provision must be made for machines landing with the wind blowing from any quarter, the landing ground must be as broad as it is long. Where machines are only likely to land occasionally, and conditions are otherwise favourable, an area of 400 yards square may be enough. For a landing ground likely to be used simultaneously by numerous machines, or where the type of machine or the atmospheric conditions necessitate high landing speeds, 600 yards square may be the minimum. Future types of machine may be able to land in more confined areas, and experience is needed before the effect of special atmospheric conditions on landing speed can be judged, so preconceived ideas of the space required must be checked by obtaining the views of pilots who know the particular machines and conditions.

Surface drainage must be considered by the sapper. If he does not think of it no one else will. Ground which may be perfectly satisfactory in fine weather may turn into a bog with the first storm of rain. The filling in of a ditch may give the required level area, but may also block the one escape for surface water and so create a quagmire. If these things happen after the sapper has passed the ground as suitable, there will be justification for the wrath of the pilot who crashes his machine on landing.

R.A.F. officers, on their part, should understand how to make their demands for work, and how the work will be carried out when approved by the division. They should also realise some of the difficulties involved in the supply of R.E. stores, and the help which they can give by making an early forecast of their requirements.

This all points to the desirability of liaison between the A.C. squadron and the C.R.E., but the employment of an R.E. officer for liaison with the squadron will seldom be possible; other and more important demands are always present to absorb every officer available for such duties, and the fact that squadron headquarters will usually be situated far back behind the divisional area makes the detachment of an officer even more impossible. Sometimes it may be practicable to effect some liaison through the corps engineer units, which will normally find themselves closer to the main squadron aerodrome than any of the divisional field companies; but the main point is that engineers and airmen

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should learn what they can of one another in peace. If each has a working knowledge of the other's job, the telephone and an occasional meeting will probably be enough to keep the Squadron Leader and the C.R.E. in touch with one another.

So much for the help which the divisional R.E. may be called upon to give to the R.A.F. The help which the R.A.F. can give to the divisional engineers will be mainly through reconnaissance.

The importance to the R.E. of early information about the jobs which lie ahead is obvious enough. Plans for work in connection with river crossings, the removal of obstacles, demolitions, the development of through traffic routes, or the consolidation of an enemy position after its capture, can only be made beforehand if they can be based on correct information. There are three ways in which the R.A.F. can help to provide such information; by direct observations made by the pilots, by taking up R.E. officers to enable them to see points for themselves and by taking photographs from the air.

The bulk of the engineer information obtained from the direct observations of pilots will be provided in response to definite requests made by the C.R.E. through the General Staff of the division. The value of the information obtained will depend largely on the way in which the request for it is framed. Definite questions usually bring definite answers; vague questions invariably bring vague answers. This point can easily be practised in the course of training; in addition, any practical experience of flying which can be obtained will assist by giving some idea of what can and what cannot be seen from the air at the heights at which service flying has to be done.

The value of the information gained by an R.E. officer, who makes a flight as a passenger to observe some special point for himself, will always largely depend on his previous air experience. The amount of useful observation which a passenger can effect on his first flight is usually negligible; on the other hand, technical knowledge might often enable an R.E. officer who is accustomed to flying, to observe points of value which would have been missed by a pilot. For this reason no R.E. officer should miss such opportunities as may come his way of gaining air experience.

The value of air photographs is sufficiently apparent—if they can be correctly interpreted. During the latter part of the war the majority of officers became fairly familiar with air photos, and learnt something about their interpretation. Since the war opportunities for work with air photos have become comparatively rare, and there must now be quite a number of officers who are inexperienced in their use. It is not difficult to learn something about the subject; there are lots of books on the war, illustrated by air photos, and a very interesting official volume on air photos

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and their interpretation has also been published, and is now in the Corps and S.M.E. Libraries. Full value is only obtained from air photos when the vertical and oblique are studied in conjunction. The latter give a much clearer idea of heights and contours. It is also worth knowing that the R.A.F. is equipped with cameras of various focal lengths, from the "8in. focal length wide angle camera" for covering a large area on one plate, up to the "12in. focal length camera," which produces a small and very detailed picture. When time permits, the R.A.F. is also able to supply stereoscopic verticals and obliques made up from selected photos. These stereoscopic photos emphasise heights and contours and may be a valuable supplement to the ordinary air photos. When asking for photographs, therefore, no less than when asking for reconnaissance, the best information will only be forthcoming if the squadron is told exactly what the photographs are required to show. Provided that they are told this clearly, the R.A.F. should be able to supply the pictures which best meet the particular case.

On their part, the R.A.F. officers can help by learning something of the sapper's work. Many words can be saved if the other fellow knows what you are talking about.

Besides the help obtained by the sapper through reconnaissance of enemy areas, the assistance of the R.A.F. is essential in all camouflage work designed to give concealment from enemy aircraft. The provision of camouflage material is an R.E. duty which seems to demand the close co-operation of the R.A.F. both in peace and war if it is to be performed efficiently. It is a duty which merits more attention than usually seems to be bestowed upon it in peace.

We have now considered how the sapper may help the airman, and how the airman may help the sapper in the course of the normal employment of each arm. There is at least a possibility that the two arms may sometimes work together for the execution of a minor combined operation. Both the R.A.F. and the R.E. are specialists in destruction, the former possessing far greater range, and the latter greater accuracy, for, however accurate bombing sights may become, dropping a ton of explosive on to a bridge can never be so effective as that same ton of explosive rightly and scientifically laid and blown. It may sometimes be feasible to combine the range of the one with the accuracy of the other.

An attack on an important bridge on the Turkish L. of C. on these lines was contemplated during the Mesopotamian campaign, though it did not materialise. The scheme was that an R.E. officer, equipped with the necessary explosive, should be transported to the vicinity of the bridge, do his work by stealth and trust to being picked up again by the plane. Since those days the development of troop carriers has made more ambitious raids a possibility which is worth keeping in mind.

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OURSELVES.

By CAPTAIN W. A. FITZG. KERRICH, D.S.O., M.C., R.E.

"I wish to emphasize the fact once more that the Royal Engineer officer must be a first-class engineer and at the same time a first-class soldier."

(Quotation from some remarks made by Lieut.-General Sir G. M. W. Macdonogh at the close of Major General H. F. Thuillier's lecture on "Engineers and the Army," given at the Royal United Service Institution, and printed in the November, 1925, number of the *Journal of the R.U.S.I.*).

I think we all know those brisk discussions that spring up now and then in places where we foregather about that most interesting of all subjects—Ourselves—what we are, why we are what we are, whether we are what we ought to be, and if not, why not.

Apart from the fact that everyone enjoys talking about himself, it must be admitted even by those outside the Corps, if they trouble to consider the matter, that the case of the R.E. Officer presents some points of interest.

Consider a typical specimen of the genus, who shows some aptitude for Survey work while under instruction, leaves Chatham to join a field company, is posted to India and becomes first a G.E., and then a Sapper and Miner, comes home and gets into the Staff College, does Staff work for a time, returns to regimental duty as O.C. a company in the Depot Battalion, goes to the Sudan to serve in the Public Works Department, and after returning home again and acting as S.O.R.E., gets some odd job like British Commissioner for the Delimitation of the Demilitarized Zones of the Straits, Constantinople, winding up his career as Chief Engineer of a Command.

He presents points of interest even if he has failed to strike out a line for himself, like the two officers who are now respectively Governor of Queensland, and Permanent Under Secretary, Colonial Office, S.W.1.

It is not as if the officer whose career is outlined above had had an outstandingly varied one. Quite the contrary, for he was unfortunate enough not to see any war service and so failed to tackle the jobs of Stores Officer, Basra; Water Supply Officer, Palestine; and C.R.E. of a division in France, or display his originality by commanding an infantry brigade. In fact the R.E. officer bears a strong resemblance to the chameleon.

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His versatility is what makes him interesting; but at the same time it makes his case correspondingly difficult to view as a complete whole, and arguments on the subject almost invariably descend from the general to the particular. A discussion that starts on the subject of whether the average R.E. officer can be expected to fill such a variety of roles with success and the best method of training him to do so, will soon crystallize out into something easier to handle, such as the need for special training in E. & M. work, or the limitation of entries to the Staff College.

The result of this is that anyone who wants to make up his mind about the more fundamental problem leaves such a discussion feeling rather empty, like a man who has eaten a few succulent tit-bits instead of a good square meal.

The question arises at this point whether there is any necessity for each of us to try to form his own opinion on this matter. Are, for example, the views of a comparatively junior officer, with no experience of big engineering jobs and no Staff or Indian service, of any value? Clearly not much; but it must be remembered that by a natural process junior officers become senior officers in due course, and will then be required to have opinions on such a subject.

There is no harm in forming opinions from the data at your disposal, provided always that you are prepared to modify them if necessary when you have gained further experience. It is encouraging to read that at the end of Major-General Thuillier's lecture on "Engineers and the Army," largely devoted to such an abstruse subject as the functions of the Engineer-in-Chief, General Sir George Milne said:—

"I see a very large number of Royal Engineer officers here to-day, and I came to the meeting hoping that I should hear some opinions, *especially from the more junior Officers.*"

Rejecting then the proffered advice of an officer who maintains that the Corps exists as it is now simply because it is a secret and mysterious society that nobody understands, and would not be half so flourishing as it is if anyone did know anything at all about it, the attempt will be made. The difficulty is to know where to begin, but perhaps the best thing to do will be to show how we are all employed to-day.

PRESENT EMPLOYMENT OF R.E. OFFICERS.

This is shown in the Employment Table which has been compiled from the "Station List" in the October, 1925, *R.E. Quarterly List*. Absolute accuracy is not guaranteed (7 officers are sunk without trace), but it is correct enough for present purposes. The *Quarterly List* was chosen in preference to *Peace Establishments* as it goes more into details, and only two parts of the latter (Nos. 1 and 3) could be obtained.

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R.E. Services (exclusive of E. & M.)	E. & M.	Railways.	Survey.	Staff, Units, Military Schools.	Engineering Instruction.	Miscellaneous.
Directorate, War Office. C.R.E's. S.O.R.E's. A.E's. (D.O's.) G.E's. (India). P.W.D. (India and Sudan). (Note. Many Fortress company officers are employed mainly on works but are not shown here).	All officers so marked in the list. (Note. The A.A. Searchlight Bn. (24), School of A.A. Defence (5) and School of E.L. instructors (6) are shown elsewhere).	Indian 36. Miscellaneous 7 (Note. The Railway Training Centre Instructors (9) and Railway Coy. officers (8) at Longmoor are shown in other columns).	Ordnance Survey 14 Survey of India 27 Miscellaneous 18	Staff officers (excluding S.O.R.E's.) 39 C.R.E's and Adjutants Divl. Engineers 6 Field Companies 65 Field Squadron 6 Sappers and Miners 105 A.A. Searchlight Battalion 24 Training Battalion 27 Depot Battalion 11 Mounted Depot 6 Students Staff College 12 R.M.A. and R.M.C. Staffs 9 Students S.O.S. 5 School of A.A. Defence 5 Territorial Adjts. 20 Fortress Companies 43 Railway Companies 8 Porton Company 3	S.M.E. and Cambridge 154 E. & M. Courses 32 Railway Training Centre 15 School of Electric Lighting 12 (Note. Both instructors and students are shown here).	Odd jobs 32 Unaccountable 7
307 57*	30 4*	43	59	394 19*	213	39 4*
364	34	43	59	413	213	43

Officers of the Royal Engineers (Indian Army), Coast Battalion, Militia, Territorial, Temporary and retired officers. Officers of the Staff for R.E. Services, Quartermasters, and A.I.R.E.M's are excluded. Grand Total 1085+84=1169.

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In order to get a birdseye view of the situation the number of columns has been restricted to seven, though it has not been easy in some cases to decide into which category certain officers ought to be put. An outstanding example are the fortress company officers who have all been put in column 5, whereas many of them ought really to be in column 1.

Every officer on the Active List, from Lieutenant-Colonel downwards, is shown, including Lieutenant-Colonels "removed from the Corps and still on the Active List," and officers on half pay who "retain their present employment."

At the foot of each column are shown certain other officers. These are officers of the Royal Engineers (Indian Army), 33 in number, and 51 Coast Battalion, Militia, Territorial, temporary and retired officers. As *Part I, Regimental Establishments* (including Works), and *Part III, Miscellaneous Establishments and Instructional Institutions*, of *Peace Establishments* alone show 1035+61=1096 regular R.E. Officers, it is presumably intended in due course to replace all these temporary etc., officers, and their inclusion gives a truer idea of the jobs to be filled.

Incidentally it is extremely interesting to note that *Peace Establishments* allow for 222 officers under instruction + 28 instructors =250 for column 6.

We see then, from the table, that about 1/5 of the whole are instructing or under instruction, and that the remainder are divided in the proportion of five to four between "engineering" and "soldiering," to use two very elastic terms. The other important point to note is the comparative unimportance at the present moment in the Royal Engineering world of E. & M., railway or survey work when compared with "works," *i.e.*, constructional engineering.

A VERY BRIEF HISTORY OF THE CORPS.

This will not go back beyond the South African War. Major-General Thuillier's lecture gives some very interesting information about the days before that, when the R.E. led a separate existence from the rest of the Army. The picture of Wellington humbly proffering advice to his engineers, to which they paid not the slightest attention, is one which should not be missed.

By the time of the South African War, however, this impossible state of affairs had been largely remedied; yet the Corps still occupied a unique position in that if there was any work to be done, from running railways to revetting trenches, that could by any stretch of the imagination be labelled "scientific," it had to be done by us.

Between the South African War and the Great War there are two events of outstanding importance. Firstly, mechanical transport was taken over from us by the R.A.S.C.; and secondly, military

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aviation, which had been in our hands, passed to those of the Royal Flying Corps.

During the Great War the situation is somewhat obscured by the fact that there were not nearly enough of us to go round, and that it was, therefore, necessary to call in the civil engineer to our aid. While bearing this in mind the following must be noted.

(*a*) The formation of the Directorate of Transport which took roads and railways out of the hands of our organization.

(*b*) The formation of the Royal Tank Corps with very little assistance from us.

Lastly, since the Great War, the Royal Corps of Signals have broken away from us and started life on their own. The lesson to be learnt from this survey of past events is pretty obvious.

We live in what has been called the Mechanical Age, in which engineering is entering more and more into our daily life. There are for example, those who affirm that a motor car, or at least a motor cycle, is no longer a luxury but a necessity.

As the engineering needs of the Army have increased, certain portions of the Corps have grown to an unwieldy size and have broken off from the parent body.

It must be carefully noted, however, that mere size has not been the only cause ; in addition there has been the necessity for specialization.

Specialization.

Specialization is a relative term of course. The lawyer, the priest, the soldier are all specialists, the outcome of finite man's efforts to cope with an infinite universe. Latterly the growth of science, using the word in its broadest sense, has been abnormal and specialists have sprung up like mushrooms in every field of human activity. Whereas not so long ago we had the leech who knew all that there was then to be known about medical science, to-day every doctor is either a physician first and a surgeon second, or vice versa. In many cases the process is carried still further and you have the Harley Street specialist who devotes his whole time to one particular disease—lunacy, for example.

The process is very clearly seen in our sister profession, civil engineering.

Everybody knows that there are three separate Institutions to which the civil engineer can belong, the Institution of Civil Engineers, the Institution of Mechanical Engineers, and the Institution of Electrical Engineers. The engineer who belongs to one of these, say the mechanical engineer, does not look on himself as a specialist at all. He uses the term to denote one who devotes his energies to steam engines or oil engines, or might even consider that the term should only be applied to the authority on one particular type of steam, etc., engine, say the marine turbine engine.

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There is, of course, no hard and fast line between the different branches of engineering, the water supply or the electrical engine expert are proof of this; but the fact remains that the civil engineer who succeeds lays no claim to being an expert on all engineering matters. He is a specialist in his own particular line, has a good working knowledge of cognate subjects, and can do little more than talk intelligently about the rest.

His training is somewhat as follows. Take the case of the young man who thinks that there is a big future for reinforced concrete. He will go to a university for two or three years and then be apprenticed to a firm for a similar period. Universities vary greatly in their methods, but, whichever one he selects, at the start he will divide his time equally between the groundwork necessary for constructional, mechanical, and electrical engineering, while at the end he will study one of the three in much greater detail than the rest. We would call this latter specializing. At Cambridge I understand that specialization is delayed till the last year of three, but that in most of the other big universities it starts at a much earlier period, the student starting to specialize before half his time is up. The process of specialization is carried on during the apprenticeship period, which in this case will be with a firm specializing in reinforced concrete. In delaying specialization to what they consider to be the last possible moment, the universities rely on this probationary period with an engineering firm to supply specialist knowledge and practical experience.

Lastly, after getting his A.M.I.C.E., and becoming a fully fledged civil engineer, he may decide to specialize still further, say, in R.C. bridges.

It is this question of specialization which is the bone of contention among the officers of the Corps at the present moment. So far the argument is that nowadays in any profession a measure of specialization is unavoidable; and that the R.E. Officer is already to some extent a specialist engineer, since he would be well advised to eschew technical arguments when dining in the messes of the Royal Air Force, the Royal Corps of Signals, or the Royal Tank Corps.

The problem of the extent to which it is desirable that the R.E. officer should be a specialist is, of course, anything but new.

Several committees have been appointed by the War Office from time to time to report on the functions and organizations of the Corps of Royal Engineers, and their pages must be studied by anyone who is really interested in the subject under discussion, as they go far more deeply into the matter than it is possible to do in this article.

It will then be seen that the problem has many aspects, only a few of which can be touched on here.

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Some Aspects of the Problem.

(1) *Finance.*

In peace time this is the most important aspect of any military problem, and we will, therefore, consider it first.

It is clearly useless to-day to advocate any change which means an increase in the Army Estimates; for example, it is useless to advocate an increase in the number of R.E. Officers. Directly after the war this was by no means the case, and many excellent ideas were put forward then, and received serious consideration, which it would be a waste of time to talk about to-day.

To give a few examples:—

It was proposed that D.O's should be entirely relieved of the duties of Quantity Surveying by a specially enlisted civilian staff: and that Fortress Company Officers should not be employed in positions of responsibility in the organization for works services.

It was proposed, from experience gained in the last war, that the proportion of R.E. to Infantry in a division should be as 1 to 6, eliminating the pioneer battalion, and making the proportion of unskilled labour in a field company 70-75 p.c.

Most important of all it was proposed that there should be an Engineer-in-Chief at the War Office with an adequate staff. It is wandering from the subject in hand, but it must be remarked in passing that the idea of having an Engineer-in-Chief at the War Office is not simply to provide the Corps with a head, desirable though that is. It is also intended to provide the Army with an organization charged with the duty of keeping an eye on its ever increasing scientific needs, and making sure that new scientific discoveries which could be of use are noted, investigated, and if necessary, developed for Army purposes. The lack of such an organization may well prove to be a severe and possibly fatal handicap in the wars of the future.

But, except in war time, Finance is an all powerful divinity before whom even the strongest must bow, whose word is law, whose frown means annihilation. Asked at his lecture how it was that in the new *War Establishments* (for small wars), a field company has only been given a small proportion of unskilled labour, and is still the little unit that it was before the war, Major-General Thuillier replied: "The authorities who are responsible for the establishment are in a very difficult position. They are being pressed very strongly to cut expenses to the very bedrock bottom. They have, therefore, to decide between providing, perhaps, more Engineers, or, alternately, providing more guns or tanks or something else." We have, at any rate, now got three field companies and a field park company to a division, instead of the two field companies that were considered to be sufficient before the war. The importance of the financial aspect of any problem cannot be over-

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estimated, and the tighter money is the more important is it that all requirements should be fully investigated and understood, in order that nothing may be spent on the very desirable at the expense of the essential.

I again urge anyone who is interested in the subject to get hold of and read the reports of the various War Office Committees who have investigated R.E. problems, especially those issued since the war.

(2) *Interchangeability of Personnel.*

It is obvious that, from the point of view of the Army as a whole, it is extremely desirable that all those services which require for their execution personnel with technical knowledge and training of the types which are included in the ordinary engineering professions in civil life, should be organized in a single Corps of Royal Engineers. (All ranks are now being considered, not officers only).

The advantages to be gained are:—

(*a*) Flexibility and consequent economy of personnel, for, on occasions when one class of work becomes temporarily the predominating factor, men and materials can be concentrated on it by depleting the numbers engaged on less essential occupations.

(*b*) Better recruitment, especially as far as the Officers are concerned; for they are thereby offered a wider sphere of work and interest, with better chances of advancement for the able and ambitious. A small Corps has few inducements to offer to such men and is unlikely to enlist them.

(*c*) Economy and convenience in administration and the elimination of the inevitable waste and inefficiency due to having a large number of small units competing with each other for personnel and material.

During the war the works in the field which came under the category considered above, as requiring technical qualifications of the types available in the engineering professions were broadly the following:—

Bridging, both road and railway.
Water Supply, including pumping installations.
Demolitions.
Construction of roads, railways, and tramways.
Defensive Works, including cover from shell fire.
General Building Works on the Lines of Communication and at bases.
Hutting and Camp Accessories.
Provision of Electrical and Mechanical Power.
Electric Lighting.

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In addition there were various technical services which do not fall in quite the same category, which must also be considered. In some cases their personnel is only partially drawn from the engineering professions, in others not at all.

The tactical employment of some of them has furnished overwhelming arguments in favour of their becoming separate Corps or being amalgamated with other arms. These services are :—

Signals.*
Railway operating.
Dock and Canal operating.
Surveys and Map production (including sound ranging* and flash spotting*).
Gas.
Searchlights.
Printing.
Postal.
Meteorological*.
Camouflage.
Forestry.
Tanks (technical branch*).

Notes on the above :—

(*a*) Those marked * are not now R.E. Services.

(*b*) It is difficult to divorce railway operating from railway construction ; for small wars at any rate, these remain R.E. Services, together with dock and canal operating.

(*c*) There is no real reason why gas should be an R.E. Service. Its production may come under the heading of " scientific " but not of " engineering."

(*d*) The printing and postal services are too small to stand alone, and are simply attached to us for convenience of administration.

Lastly, in addition to the above, it must be remembered that there are the unknown future engineering and technical requirements of the Army to bear in mind when considering the functions of the Royal Engineers. The usual practice is to entrust new scientific and technical services to the Corps at the start, and then either incorporate them into its permanent organization, or form a separate Corps of them if they become sufficiently large and important.

(3) *Education of R.E. Officers.*

There was general agreement when the war was over that the pre-war syllabus of education was producing an R.E. Officer with an insufficient technical equipment for modern engineering. Eminent civilian engineers who were consulted were insistent on this point, while speaking highly of our ability. The outcome of the controversy was what is known as the Cambridge scheme.

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In 1924 the report of the Haldane Committee on the Education and Training of Officers was published.

This report recommended the following :—

Programme of Courses at Chatham and Cambridge for R.E. Officers.

S.M.E. for the following courses :		
Military duties	10 weeks	
Fieldworks	15 ,,	
Survey	12 ,,	
Workshops	8 ,,	
Electricity	3 ,,	
Leave	8 ,,	
	—	= 56 weeks
Cambridge.		
3 tours (and 2 vacations)		35 weeks.
Leave	3 weeks	
S.M.E.		
Construction	8 ,,	
Refresher, Military Duties	3 ,,	
Leave	3 ,,	
	—	= 17 weeks.
Cambridge.		
3 tours (and 2 vacations)		35 weeks.
		143 weeks.

These recommendations are now to be put into force with certain minor modifications.

Among the ideas which came up for consideration before the new scheme took shape the following are of interest :—

(*a*) That Sandhurst and Woolwich ought to be combined, in order to eliminate the idea that the sapper or gunner officer is altogether different from the product of Sandhurst.

The cost of moving the Woolwich establishment to Sandhurst was said to be very great, and there were obvious educational difficulties.

(*b*) That on leaving Woolwich the young R.E. Officer should go to a field unit for six months.

(*c*) That as many of us as possible should, during the first ten years of service, be sent to representative engineering firms in Britain or the Dominions, Crown Colonies or India, to undertake some responsible job and get acquainted with the practical work that is going on in the civil engineering world.

This project, however desirable, is obviously impracticable for financial reasons: the Cambridge scheme, it must be noted, was only made possible by reducing the time at Woolwich from two years to eighteen months.

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Summary and Personal Opinions.

No great and successful work, whether it be something concrete like the Taj Mahal or a piece of organization such as the despatching overseas of the Expeditionary Force, was ever accomplished unless those responsible for it were inspired by a high ideal; no work can be done at all unless the worker has some picture in his mind's eye of what he hopes to accomplish, while a low ideal means poor work like the creations of a jerrybuilder.

Imagine for a moment that in a promotion examination one was asked to define the ideal R.E. officer in a single sentence. I suggest that one would get full marks for replying "a first-class all-round engineer and a first-class soldier," and I am definitely of the opinion that the time has now come when this answer should no longer be awarded full marks.

This may seem inconsistent, since it is a high ideal if ever there was one; but it must be remembered that there is another and extremely important side to the picture, and that is the discouraging effect exercised by an ideal that is too high. A simple example will illustrate this. Take the case of a young man who discovers that he possesses a turn of speed over a short distance, and joins the local running club to develop his abilities. If his ideal is only to run faster than his club mates he will never become a big noise in the athletic world, while if on the other hand his ideal is to run as fast as a greyhound a few trial spins will result in his resigning his membership through sheer discouragement.

Clearly the right ideal for him is to break the record for his particular distance, for, while the odds are greatly against his ever doing so, the effort will develop his powers to the uttermost.

To return now to our own case, the march of events has in practice forced us willy-nilly to abandon the all-round ideal: anyone who denies this must deny the existence of the Royal Air Force and the Royal Signal Corps. What then is the use of clinging to it in theory? Let us at least acknowledge that the R.E. officer is a specialist to the extent that he is only expected to be master of constructional engineering, railway engineering, and survey work in all their various branches, electrical engineering (signal work excluded), and mechanical engineering (with many important branches excluded)

Granted all this, it may seem that such an one is still entitled to call himself an all-round engineer, especially when it is remembered that he has to be prepared to meet any hitherto unforeseen developments in electrical and mechanical work, and that this is little better than quibbling.

I will now put forward a further and more cogent argument, namely, that in reality the average R.E. officer is only expected to be a first-class constructional engineer. When he is required for

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other work, he is in the majority of cases given extra training, and then devotes the rest of his life to that particular branch. This has been the case for a long time as regards Indian Railways, the Survey of India, and the Ordnance Survey to a more limited extent, and these employ the majority of railway and survey officers. A certain amount of interchange goes on with the rest of the Corps due to fluctuations in numbers (on survey commissions for example), unsuitability for the work, or the desire to go to or return from India; but the statement that Railway and Survey Officers are whole time specialists holds good in general. Very naturally all the higher posts in these branches are held by such officers.

If the above is not true of E. & M. work at the present time, it very soon will be; the proof lies in the fact that 32 officers are now undergoing a two-year specialist course in this work. Two years is so long a time that, at the end of it, it will be highly uneconomical to employ these officers on anything but E. & M. work; while on the other hand it is clear that the average officer, who has not been through this course, can no longer pose as an expert where E. & M. work is concerned.

These three, Survey, E. & M. and Railways are the only branches of engineering outside Construction to employ enough of us to merit attention here.

The total number is comparatively small, say 1/3 of those employed either on ordinary works services or with units. It has been explained above why small bodies of specialists such as these are retained in the Corps; while past experience shows clearly that should any of them grow in importance, as might very conceivably occur in the case of the E. & M. branch, they are bound to break away from the rest of us.

On account of their small size they are in a privileged position in that, without involving too great a strain on the Army Estimates, they can give their officers extra tuition before entrusting them with responsible work.

I am, therefore, of the opinion that the time has now come for the great majority of R.E. officers to adopt as their ideal "A FIRST CLASS CONSTRUCTIONAL ENGINEER AND A FIRST-CLASS SOLDIER," replacing the word "constructional" by "railway," "survey" or "E. & M." in the case of the remainder.

This seems to me to be legalizing a state of affairs that exists in actual practice and to be in no way revolutionary; but, be that as it may, I consider it an absolutely essential step to take, for I believe that the official "all-round" ideal is having a prejudicial effect on the Corps at the present moment. Firstly, for the reason that ours is a calling that demands high resolution and earnest endeavour if we are to render ourselves fit for the tasks that lie before us, and it is inevitable that resolution should weaken and endeavour grow

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slack when faced by an impossible task. More is demanded of us than the efficient performance of our daily avocations; but it is not encouraging, to say the least, to an officer who is prepared to work in his spare time to be told that the whole field of engineering has got to be covered in addition to mastering the art of waging war. Confronted with this situation there is bound to be a tendency to be content with passing promotion examinations, and cultivating the art of talking convincingly about matters that in reality one knows nothing about.

If anyone thinks that the ideal I advocate is not a sufficiently high one let him talk it over with a competent civil engineer, and start the conversation by explaining that about half his life is going to be spent performing military duties which involve little or no high-grade engineering practice.

In the second place it appears to me that if the all-round ideal were officially discarded a change would follow in the system of educating the Y.O. Education is a thorny subject for the amateur to tackle; but it is impossible to ignore it in this connection, for it has been acknowledged that the system of pre-war training is not good enough for present needs; a programme of the present course of instruction which is to remedy this state of affairs is given above. The solution of the difficulty that has been adopted is to increase the period of instruction from two years to nearly three years, and send the Y.O. to Cambridge for his theoretical instruction. At Cambridge, if the experience of the Supplementary Classes who went there is a correct guide, the Y.O. will devote his time equally to (the theory of) construction, electricity and mechanics. At Chatham the time spent on construction is only to be one quarter of that devoted to (practical) instruction in E. & M. work, and a very thorough course of survey.

As a generalization I am in agreement with the dictum that specialization breeds a narrow outlook, and should be delayed to the last possible moment; but surely this is carrying things too far if it is agreed that the officer for whose benefit the programme has been got out is to be a constructional engineer only, as most of us have to be. It differs widely from the method of training the young civil engineer who spends only half or less of his time at college on his all-round education and then proceeds to specialize in one of the three branches for the remainder. Surely our present programme must be the practical expression of an all-round ideal. There is not a hint of specialization in it, and remember that in our case there is nothing corresponding to the apprenticeship period of the civil engineer, which is always devoted to specialization.

I advocate taking at least nine months away from the time at present devoted to electricity, survey and mechanics and devoting

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it to construction (even if this means the severing of our connection with Cambridge).

How these nine months should be spent is a different problem. Personally I would devote it to practical experience of big constructional engineering work. It is practical experience, not books, that teaches one the great fundamental principles of engineering to which reference is so often made and which I really believe some people think are Newton's Laws or something of that kind. To quote from the discussion after the lecture referred to above "In engineering operations you have to consider five things (i) the skilled labour available (ii) the unskilled labour available (iii) the time (iv) the transport and (v) the stores and plant. All these details have to be proportioned and co-ordinated." The remarks were made in quite a different connection and referred to engineering in war-time, consequently no mention was made of (vi) the money available; but the words serve admirably to illustrate what I want to say. Advanced theory on the other hand can be acquired from books in after life: not an ideal method of course, but then time is so limited with us. I would point out that my proposals involve no extra financial strain. Indeed, if the practical side is studied in a government department which has suitably big new work in hand, there will be a considerable saving. If civil firms were selected in preference to government departments, on the ground that one's outlook would be more broadened thereby, there might still be a small saving over the present scheme.

It is clear that this practical training must be given during the three years allotted to instruction if it is to be given at all. Financial considerations will not permit of any extension of the training period.

Lastly to consider the question of interchangeability. I think that the man who has thoroughly mastered one branch of engineering and gained confidence in himself and in his ability to get things done, is more likely to be a success when he is transferred to work of a totally different kind than one who only has a half-knowledge of both.

All officers might as well take the course I have outlined. Survey officers would only require an additional survey course. Railway and E. & M. officers already get a good specialist training. The nine months' practical experience might perhaps in their case be with railway companies or firms specializing in E. & M. work, but I think it would be better if they went through the same process as the rest.

CONCLUSION.

Two ideals other than those discussed above have always had their advocates and must in conclusion be briefly examined.

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Throughout the above the "first-class soldier" part of the programme has been taken for granted, though clearly it adds enormously to the difficulties of the situation. It is obvious that it is much easier to be a tip-top engineer if you do not have to be a soldier as well, and vice versa; in fact some say that it is impossible to be both even when you have got rid of the word "all-round."

Those who maintain that this is so are from the very nature of the case divided into two opposing camps.

In peace our time is divided almost equally between training for war and working as engineers pure and simple (cp. the Employment Table, page 227). In war a very similar dividing line appears, and *Field Service Regulations* differentiate clearly between field engineering on the one hand, which is what those now organized in units are training for, and works services which differ only in degree from works services in peace.

F.S.R., Vol. I, paras. 66-73, and 43 should be studied in this connection. It will be seen that the dividing line between the two is quite reasonably distinct, though not absolutely hard and fast of course. These facts lead to the formulation of two new ideals. One is "a first-class engineer with a good knowledge of Army needs," the other is "a first-class soldier with a sufficient knowledge of rough and ready engineering."

Take the latter first. Those who uphold it will argue somewhat as follows. "Soldiering as it is to-day is a whole-time job, and we are lowering our efficiency by making a half-time job of it. Every soldier nowadays is a specialist of some sort, and at the same time has to know what all the other specialists can do in order to work in with them. Constant intercourse and combined training are necessary to attain this result. D.O. work and all that kind of thing cause us to lose touch and incidentally lower our prestige, for who can be expected to regard the man who keeps his drains in working order and refuses to give his room a fresh coat of paint, as a brother officer? We have always prided ourselves on being a combatant corps but others see us in the guise of an administrative service; and we are severely handicapped thereby when we compete for the higher posts in the Army. The vital services which we are called on in war to perform are three in number, communications, water supply, and demolitions. No vast amount of engineering skill is required for these under front line conditions where speed is the essential, cost is a negligible consideration, and it doesn't matter how rough and ready the work is so long as it functions during the short time for which it is required. Bridging too, has been much simplified by the introduction of stock spans. There should be no difficulty in teaching what is required of the field engineer in suitable field-work schools. Works further back, where

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conditions approximate to peace time, can be performed by civilian engineers."

The other side reply on these lines, "Soldiering is not nearly so difficult an art to master as you make it out to be, not nearly so difficult as engineering. A capable engineer will pick up all that you say is required in the front line in less than no time, and, what is more, will do it a great deal better than the product of the field-work school, who, in fact, will be merely a pioneer.

If you expect to raise the prestige of the Corps by becoming pioneers you will find yourselves sadly mistaken. What do you mean when you talk about being a combatant Corps? If you have got any war service you know perfectly well that in an advance the R.E. are stretched to the breaking point working on communications, and that in position warfare the Higher Command will not allow us to be expended on hand-to-hand fighting. In a retreat, of course, you may be called on to act as infantry if the situation is sufficiently critical, but in that case so will everyone else within reach, whatever his normal duties are. You are quite on the wrong tack, the paramount need of the average R.E. officer at the present moment is to devise some way of increasing his technical efficiency."

When we come to consider the arguments roughed out above, it is at once obvious that there is very little in them if it is possible for the R.E. officer under present conditions to be efficient at both engineering and soldiering. Both protagonists are clearly of the opinion that it is not possible.

Now, apart from those under instruction, the employment table shows that, in order to perform their peace time duties, about half the Corps must be efficient engineers, while the other half must be efficient soldiers.

It follows then that there is only one possible solution of the difficulty, and that is for each officer to spend his whole time becoming either one or the other. Since the two resultant types would no longer be interchangeable, the Corps would become two Corps.

It has been shown above that from the point of view of the Army (which is the only thing that really matters), this would be a most undesirable state of affairs, and it will, therefore, have to be very clearly proved that it is impossible for each of us to be both a first-class engineer and a first-class soldier before the Corps will be allowed to break in two.

Personally I have only tried to prove that it is not possible to be every sort of engineer and a soldier as well, and have no wish to go any further. If there really are any who do, it seems to me that they are unfortunate enough to have missed their true vocations. They should either have become civil engineers or joined another arm of the service.

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A BRIDGE OF BOATS OVER THE RIVER INDUS.

Photo 1. Commencing Shore Bay.

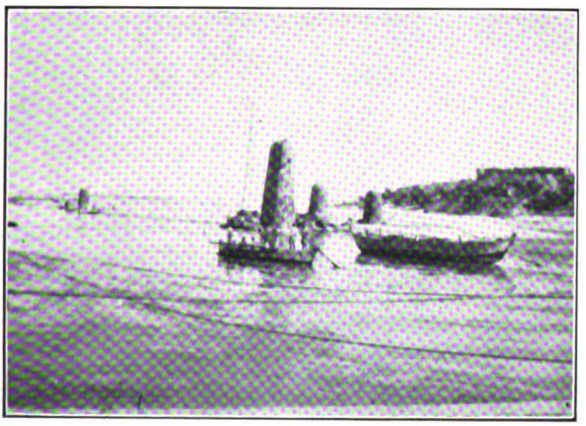

Photo 2. The anchor party.

Photo 3. The towing party.

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Photo 4. Bridge complete.

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A BRIDGE OF BOATS OVER THE RIVER INDUS.

By CAPTAIN C. DE L. GAUSSEN, M.C., R.E.

THE bridge described in this article was built over the River Indus for the Northern Command manœuvres in November, 1925. The permanent road bridge, which runs below the railway bridge of the main N.W. Railway line to Peshawar, besides being closed when trains are crossing, necessitates travelling an extra five miles of road length down and up the river valley, and would have caused a bottle neck which would have resulted in great delay to troops from the Peshawar side approaching the scene of operations. It was, therefore, necessary to bridge the Indus just above Attock Fort, where the roads on both banks join the river valley. This operation of bridging, which was entrusted to 19th Field Company Royal Bombay Sappers and Miners, brought out some interesting points which may be of use to other officers.

The bridge was required to carry all but heavy loads, which had to use the permanent bridge, under the railway line.

The site selected was in proximity to that used for an old bridge of boats which existed before the railway bridge was constructed. There were, therefore, quite fair metalled approach roads, which only required patching, to within about 200 yards of the shore on each bank; below this no road can stand, as the difference of flood (July) levels and winter levels is about 50 feet. The immediate approaches were over loose sand, particularly on the east bank, where it was almost quicksand on a level stretch until it meets a high wall of rock cliff. On the west bank the shore slopes at about 1 in 6 and the sand is much too loose to allow of wheel traffic over it. Construction was carried out from this bank. The river level was sinking rapidly at the time of bridging and the actual gap bridged was 630 feet (measured by pocket sextant) and, though probably at its annual minimum, the current in mid-stream was seven to eight miles an hour. Statements as to the depth vary from 40-ft. to 70-ft.

As will be seen from the photographs, there are a number of masonry pillars up-stream of the site, which are relics of the old bridge of boats. Their position does not seem to follow any rhyme or reason and no direct use was made of them, though they were of assistance in a minor way.

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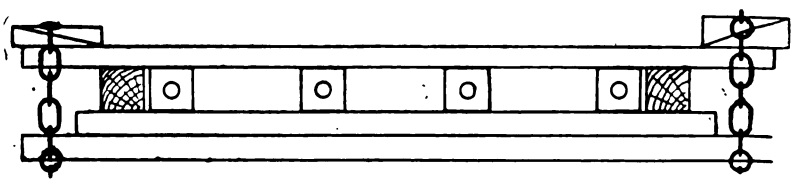
The material used was collected from bridges at Jahangira and Nowshera over the Kabul River, a tributary which joins the Indus about a mile up-stream of Attock. The boats are of two patterns, though there are variations within the patterns. The smaller boats, or Jhelum patterns, are 35-ft. long, and the larger, Attock pattern, about 60ft. completely decked, and require considerable skill in handling in the strong current. When not in bridge the boats are propelled and steered by heavy "oars" manipulated by two men standing, and consisting of long spars with planks lashed on as blades. These large boats are essential to withstand so strong a current and to provide stability on a long bridge. The large boats had scow bow and stern and the small boats full bow and stern. Road bearers were four trussed beams 33ft. long, requiring 14 men to carry them, designed for gunwale loading. The span between boats was 30ft., and astride the boat 10ft., for which the inside road bearers (called crossbeams to distinguish them) were 12ft. 6in. by 6in., but the outside ones 25ft. long. Between boats near bow and stern were distance pieces with prongs which fitted over and were lashed to bollards on the boats. These add a great longitudinal stiffness to the bridge and, in default of any means of holding the road bearers to the gunwales, keep the boats in position. On either side of the boats, a stiffening beam is placed, below the road bearers and the projecting ends of the outside crossbeams, astride the boats and kept in position by chains joined above the roadway planks and tightened by means of chocks, thus :—



It is on these that the stiffness of the bridge depends almost entirely, and if properly adjusted they function excellently, as they allow just sufficient play for the boats tilting slightly and for the ends of road bearers sinking. This design is very satisfactory and requires only proper cleats to be put on the road bearers and slots made in the gunwales in which to fit them.

The roadway planks were 2in. thick and generally 15ft. long. A proportion had stancheons fitted to take handrails, for which spars or scantlings were used. Similarly ribands were made of any suitable timber available, racked down with plain wire.

For construction purposes, small country dog-boats were employed. These are similarly rowed and steered by heavy oars manned standing. It was necessary first of all to train men in rowing these; the difficulty is to impress on them the necessity

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of using their whole weight. The steering is a real art as practised by the Attock boatmen, an experienced and hardy class of men, a party of whom gave invaluable assistance in all the work, as far as knowledge of the river and its dangers were concerned. In steering a boat across the river they keep it at such an angle to the current that it crosses almost straight, exactly as a flying boat, and the crew simply keep sufficient way on to prevent her from being carried down stream.

It was decided to build the bridge of 14 boat piers and two trestle piers, with a subsidiary short trestle pier on the east bank, as the sand was so soft that it had to be dug back until firm enough to take a shore transom, which consisted, on both banks, of large buried baulks. The pace of the current and depth of water precluded the use of anchors, so the boats had to be moored to steel wire cables stretched across the river. These were ⅞in. plough steel wire, especially loaned from the Khyber ropeway stores, each coil being 440 yards long. Their weight, stiffness and inflexibility made them very difficult to handle, especially when contesting with the strong current at the same time. Three of these were to be stretched across for the main mooring cables, and, in addition, one was stretched over each of the bows and sterns of boats and made fast to boats' thwarts, to add stability. It was found more satisfactory to place the main cables well up-stream of the bridge and not have them all along the bows of boats, as is the local practice. By having them clear of the boats, it is possible to dress bridge better, and makes no difference to the steadiness of the bridge. In addition, it very much simplifies taking boats out, should it be necessary. The anchorage for the main cables on the west bank was a buried log, 16ft. long, 2ft. diameter, buried 8ft. in the ground. Fortunately, rock was struck about 3ft. below the surface of the sand, otherwise it would have been necessary to bury sleepers longitudinally on the face of the baulk. On the west bank iron ring bolts (relics of the old boat bridge) fastened in the rock cliff were made use of. One was blasted out, to judge of their strength, and found to have a shaft 4in. diameter, buried 3ft. in the ground, and had been fixed by molten lead poured into the hole bored in the rock. Each cable was, nevertheless, taken to a different ring, and turned round a thimble forged on it. Though the tension in the cables was never actually measured, it appeared to be very much less than that calculated for as the normal strain, as there is a very considerable longitudinal stiffness in the bridge which relieves the pull on the cables.

The method of getting the cable across was as follows:—A 1½in. rope, about 200 fathoms long, was run along the bank, one end made fast to a holdfast and the other taken on a small boat about 250 yards up the bank, and the spare very carefully coiled. Two other

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small boats were placed at equal intervals along the rope. The first boat was rowed out by picked rowers, and the rope paid out as they proceeded across. Directly there was danger of the belly in the rope, caught by the current, dragging them down stream, the second boat swung out to buoy up the line, and similarly the third. Meanwhile a party had been sent across the river beforehand, and waded in as far as they could to meet the first boat, got out the end of the line and ran away with it, to get it tight as quickly as possible before it was carried down. The line was then tightened and made fast.

Next a series of loops of plain wire were hung on this line, and ½in. steel wire cable threaded through them, tightened by a block and tackle stoppered on to it, and made fast. The rope line was then removed. The first ⅞in. steel cable was then loaded on to one of the smaller type of the bridge boats, which was warped along the light cable and the heavy cable attached to it at about 30ft. intervals by lashings tied in draw hitches. After making fast, the draw hitches were released by a party working themselves along in a boat. The cable was then tightened as before and then the next cable similarly attached, and similarly the third. The greatest difficulty was encountered in controlling this heavy and stiff cable and at the same time keeping the boat up to the wire. Some sort of capstan, or axis on which to revolve the cable coil is essential, otherwise appalling kinks form at once. The other essential is to keep the cable out of water, by interpolating small buoying boats at intervals. The cables were tightened equally in turn between these supports, until all hung in the same catenary, being firmly bound at each boat and the difference adjusted in the last bay at the anchorage. They were left sufficiently loose to take up an estimated horizontal dip of 1/10 when boats' weights were on them.

The stores were next floated down from the Kabul River, and boats collected just down stream of the bridge site in the order in which they were to come into the bridge, *i.e.*, small ones at either end and largest in the centre. The superstructure was made up into rafts and floated down. The steering of these rafts with four heavy oars is no mean accomplishment, and if once caught in the full current on a straight reach there is little chance of pulling out before a bend is reached. The first raft was thus caught, and crashed into the cable which tore all the oars away, the men just saving themselves by lying flat. The raft was eventually brought to shore some two or three miles down the river. After this, a long line of 2in. cordage was kept ready at a promontory about 300 yards upstream of the bridge, to be taken out by a small boat to the raft crew, who could then be towed in to shore.

As far as the clumsiness of the equipment allowed, bridge con-

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struction was based on forming-up drill for pontoons. The detachments were as follows :—

(*a*) Boat party. Towed up boats, with two men at each of the steering oars. Owing to the strength of current, the towing rope must always have a turn round a bollard of one of the boats in bridge. The boats, too, must always be kept by the steerers pointing directly up stream.

(*b*) Anchoring party, working in a small boat along the steel wire cables. Taking two turns round the cables in the centre of 3in. falls, they let themselves down stream on this, handed the ends to the party which had towed the bridge boat up to the head, who then belayed in the ordinary way. The anchor party then pulled themselves up again, on the 3in. fall to the cable ; here again very skilful steering is necessary to insure that the boat is always directly up and down the direction of current. A slight mistake was made once with almost disastrous results, though no lives were lost, owing to the boat capsizing. The anchor party attached falls thus at 40ft. intervals along the cables.

(*c*) Construction party at the head of the bridge, ten men got into the foremost boat and ten remained on the boat at bridge head. The two outside road bearers (inverted) were placed astride the two boats and the forward boat party pushed themselves out on these, until they could be placed the right side up. Distance pieces were then slid out on them, the prongs placed on the bollards on the two boats and lashed, and tie lines made fast between the two boats at bow and stern. To place the inner road bearers, a spar with lines fore and back was placed astride the outside road bearers already in position, and the inside ones, one at a time, inverted and placed with end about 3ft. beyond it, and thus slid out. Of course, preventer ropes must always be attached when dealing with these heavy members.

One of the greatest difficulties was the alarming angle to which the boats tilt when the weight of superstructure is only bearing on one side. This can be partly lessened by not laying chesses completely in the first instance, and by keeping all superstructure and carriers well back on the bridge until actually required. A man had to be put on continuous bailing duty directly each boat was brought up to bridge head, and was kept pretty busy while the boats were thus leaning over.

The cross beams, over the boats, and tie beams were then put in as described above, and the chains tightened by means of chocks by a party following behind.

(*d*) Stores party bringing up superstructure exactly as in pontooning, on the command "chesses," "baulks," etc. The only requirements in this are organisation of traffic and muscle. A good

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N.C.O. was necessary on shore to control the material taken away and warn parties what to get ready.

The strength of parties is impossible to lay down as it varies largely with the length of bridge already constructed, the size of boats and strength of current, but the following was an average :—

Boat Party	.. ..	2 subsections.
Anchor Party	.. ..	1 sub-section.
Building Party	.. ..	4 sub-sections.
Stores Party	.. ..	5 sub-sections.

There were, too, other constant calls for men, such as bailing and caulking boats (day and night), unloading rafts of superstructure as they arrived, and bringing up the material from the raft which had " taken charge."

Handrail stancheon roadway planks and handrails and ribands were not put in until the whole bridge was completed, as they hinder the carriage of materials greatly.

On the advice of the local boatmen, two of the large boats were put into bridge stern up-stream (the difference of bow and stern is only slight), partly to make the bridge more steady and partly in case of a storm and gale from the south, not a rare occurrence. Another aid to stability and to getting an even pull on the bridge for dressing, is to tie chesses dragging in the water at every fourth bay from the sterns of boats.

The finishing of the bridge brings out no points of interest. Side screens and grass (which should be damped) were provided for the benefit of the animals. Of the thousands that crossed in the course of a few days not a single one caused any trouble. The effect of traffic is, of course, to loosen tie beam chains and riband lashings and to make the chesses creep sideways, and maintenance parties were on duty day and night adjusting these.

A ½in. steel wire cable was stretched across the river about 100 yards up-stream of the bridge and buoyed at intervals, as a guard against stray logs that might float down. There was no chance of stopping them when going at full speed, but it checked them sufficiently to render it easy for men to poke them off by long bamboos to between boats, otherwise a heavy log would make a very nasty hole.

Work on erection was not continuous owing to having to collect the material, but the following were the times taken for various parts of the work :—

Getting cables across, anchored and made fast—20 hours.

Actual erection from shore transom to shore transom—18 hours.

The approach roads over the sand were given a slope of 1 in 10, and corduroyed continuously, with grass laid on the timbers. No motor vehicle had any difficulty in passing up and down them.

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In peace it is the regiment that is the standard unit, for the following reasons :—

(*a*) To concentrate command.
(*b*) To concentrate instructional equipment, workshops, and fieldworks ground, so as to economize as much as possible.
(*c*) To centralise and reduce administrative staffs.

Thus the regiment consists of several battalions, each of a varying number of companies. The company is divided into sections and the sections into squads. The strength of a squad varies usually from 12 to 16 men, commanded by an N.C.O.

Instruction of the Sapper and Miner Recruit.

On joining their regiment the recruits are posted to companies. The instruction is divided into two periods :—

(1) First period of six months, at the end of which the recruit must :—

(*a*) Understand his duties as a soldier.
(*b*) Be familiar with the use of the weapons, gas masks, tools, and implements which he may be called upon to use in the field.
(*c*) Be able to march 15 miles in field service equipment.
(*d*) Be perfectly familiar with squad and section drill.
(*e*) Have carried out certain technical exercises.

During this period the instruction is carried on in such a way that the soldier may be ready to take the field, if necessary, at the end of four months.

The " élèves-caporaux " as in the infantry, are picked out and receive a special training.

The training of the recruit is divided into two parts, Theoretical and Practical.

During this first period the proportion is as follows :—

Practical $\frac{1}{8}$ of the first month's programme.
$\frac{1}{2}$ of the second month's programme.
$\frac{3}{4}$ of the third and fourth months' programme.
Whole of the fifth and sixth months' programme.

(2) The second period, lasting until the soldiers are liberated, consists of :—

(*a*) Instruction of N.C.O.'s class.
(*b*) Completing the technical and military training of the recruit.
(*c*) Carrying out technical and military exercises in the field.
(*d*) Annual manœuvres.

This period is essentially mostly practical instruction.

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The practical programme for the whole of the recruits' training is allotted as follows :—

(*a*) Fieldworks—$\frac{1}{8}$ total programme.
(*b*) Mining and Demolition—$\frac{1}{4}$ total programme.
(*c*) Light Bridging—$\frac{1}{4}$ total programme.
(*d*) Pontooning—$\frac{1}{4}$ total programme.
(*e*) Roads and Communications—$\frac{1}{8}$ total programme.

SPECIALISTS AND ARTIFICERS.

The general instruction given to all recruits does not allow for the training of the specialists and artificers essential to a Sapper and Miner field company. These are trained separately at central training centres, which are drawn on as required by the field units.

Thus each battalion or regiment picks out likely men and sends them to—

Versailles, to be trained as mechanics ;
Bourges, to be trained as trade artificers ;

and so on, where the men receive special instruction.

GAMES.

Sport has developed considerably in the French Army since the war. In addition to daily P.T., the men play rugger, soccer or basket-ball two or three times a week. Each battalion, regiment, etc., has its rugger and soccer teams, and garrison tournaments are held regularly.

For hill-work in winter, units stationed along the east frontier are provided with skis for a definite proportion of their total strength, and, when the snow is suitable, ski-ing is a favourite pastime amongst both officers and men.

Rugger and soccer, especially the former, have also made great strides among the civilian population, and every town of any importance has its representative team.

That the Frenchman wishes to introduce the correct spirit into his games is shewn by the following notice that one sees frequently pasted up at football grounds :—

Au Public.

" Le vrai sportif est toujours maître de ses nerfs, se réjouit dans la victoire, accepte loyalement la défaite.

L'arbitre n'étant qu'un homme peut ne pas tout voir, peut même se tromper.

Les arbitres n'étant pas payés sont droits au plus grand respect.

Injurier un arbitre ou un joueur n'est pas digne du vrai sportif."

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NOTES ON MILITARY RAILWAYS.

By MAJOR E. ST. G. KIRKE, D.S.O.

R.E. OFFICERS are sometimes called upon to construct or maintain military railways at short notice, and it is not always possible readily to obtain the necessary information. In such cases the following notes based on the construction of several hundred miles in different parts of the world may be of some small value.

Military railways differ from those built for civil purposes in that if they are wanted at all they are wanted in a great hurry. A certain amount of experience of railway construction under active service conditions is necessary to decide in what respects civilian railway practice can be ignored, without the safety of the troops being endangered.

ALIGNMENT.

The shortest distance between two points is known to be a straight line, and the location of a railway would present no difficulties if this could always be followed. But hills, valleys, rivers, woods, towns, etc., conspire to make this impossible in practice, and the military engineer has to weigh up all the factors and get his line in as quickly as he can, provided that it is up to a standard which will fulfil the purpose for which it is laid.

An eye for country is essential, particularly when the latter is unsurveyed, and a quick decision must be made as to whether time can be saved by a longer alignment with easier curves or gradients, or by a straighter line which involves heavier earthwork with possibly sharper curves and steeper gradients. All the time he must keep in mind the capacity of the engines and rolling stock which are to work the traffic, and the quantity and quality of the labour which is likely to be available.

It will seldom be possible to make plans of a military railway before construction begins, and, in fact, construction parties will usually press hard on the heels of the survey. For the latter the most essential instrument is a level, with a clinometer to give a rough idea of slopes. As regards direction, a straight line can be laid out with field glasses and ranging rods to an accuracy of about a foot per mile, and curves can be set out by offsets as will be described later.

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EARTHWORK.

Assuming that the alignment has been satisfactorily settled, the "formation" can be got on with. It goes without saying that the lower the banks and shallower the cuttings, the quicker will the line be made. In flat country, not liable to floods, the permanent way can even be laid upon the ground, with only such packing or ballasting as will eliminate inequalities of the surface (Fig. 1.)

The method of forming the bank or cutting will depend upon the kind of labour available and the nature of the soil. When there are rocks about, cuttings should be avoided, as blasting will probably be entailed, which interferes with the neighbouring working parties. Boulders up to three feet in diameter can sometimes be split by heating them and pouring over water, if other means of removal fail.

In average soil horse-drawn scoops are very useful for shifting earth, but pick and shovel, or Indian "pharwas" will be the tools most generally used. When the bank is not more than two or three feet high, earth can be dug at each side of the line and thrown into position. With European labour wheelbarrows or tip-waggons on 2-ft. track would be used for higher banks; baskets or donkeys when the labour is African or Oriental. (In this connection it may be mentioned that metal bowls are better than the ordinary Indian wicker basket, as they last much longer, and are available when not in use for the storage of water in camp.) While earthwork is going on, it should be the business of some named person to see that the centre line is properly maintained, or it is certain to get a foot or more out of place.

BRIDGES.

These are probably the most interesting feature of railway construction, and sometimes the cause of much "heavy weather." From the military point of view, they are vulnerable; generally need guarding; and should, therefore, be reduced to a minimum in number. When possible culverts should take the form of pipes, whether of concrete, galvanised steel, or wooden boxes, covered over with earth. In this form they are difficult to see, and practically invulnerable from the air.

If the bridge is so situated that a guard has to be provided, time may often be saved by extending it at each end, so as to reduce earthwork. Under ordinary conditions of work a viaduct is quicker to build than an embankment of about eight feet in height.

Military bridges, like others, involve consideration of foundations, piers, and superstructure. The simplest form of bridge is when girders can rest on a timber raft on each bank, well above the water-

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This service is divided up into three periods of six months each.

1. Preliminary period of six months.
2. Six months at St. Maixent or St. Cyr.
3. Six months with a regiment.

There are two alternative methods of carrying out the preliminary period :—

(*a*) If at a university he can undergo what is called a " préparation militaire supérieure," which consists in attending lectures on military subjects given by officers specially told off for the purpose, and in carrying out certain military exercises.

(*b*) Those who do not undergo the " préparation militaire supérieure " must enlist for six months, when they are put in a special platoon, one of which is kept for this purpose in each " corps d'armée."

In either case, (*a*) or (*b*), the would-be officer has to pass an examination at the end of six months in order to enter either St. Maixent or St. Cyr.

Students for certain professions, such as doctors, lawyers, etc., are permitted, on application, to do their 18 months' service several years after they reach the age of 20, so as to prevent their studies being interrupted at a critical period.

Having completed his compulsory service and been liberated, the reserve officer returns to civil life and comes up again for so many weeks' training every other year according to the existing regulations. He does this training when he chooses, but not necessarily in the same unit as the one in which he did his original service, although he naturally keeps to the same branch.

There is no system of officers' messes in France, and consequently no accommodation for single officers in barracks. All the unmarried officers of a battalion, etc., live in lodgings in the town and foregather for the two meals of the day, at noon and in the evening, in one of the local restaurants, where they arrange to pay by the month. Naturally there is no mess kit for the evening meal, mufti or service dress being worn.

There being no messes, the system of calling is different from what it is in England. An unmarried officer arriving in a station calls only on his own commanding officer—as I discovered after an attempt to call on the gunners in the garrison, when I spent a considerable time at their barracks in a fruitless attempt to explain the reason for my visit.

Most garrison towns have a " cercle militaire," or officers' club, consisting of a restaurant, reading room, library, etc. ; and where,

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during the winter, weekly or fortnightly dances are held, the officers of the garrison bringing their partners.

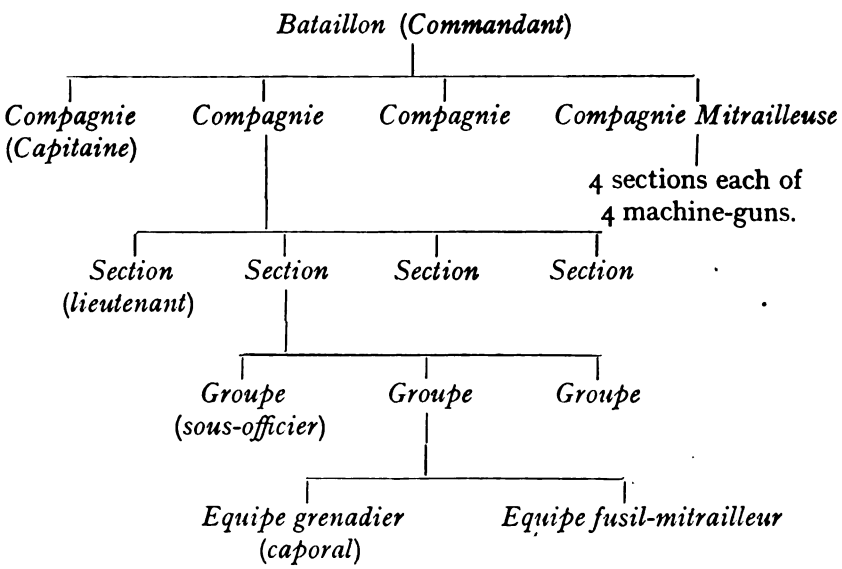
Riding, fencing, bridge playing in the cafés, dancing in the local casino or its equivalent, and the theatre or opera if there happens to be one in the station, constitute the main relaxations for the average officer.

INFANTRY TRAINING.

The recruits come up for their 18 months' service at the age of 20, joining the battalion to which they have been posted in the middle of November.

The Chasseurs enlist men suitable for the arduous hill work of the frontier, men who have usually been born and brought up in the hills. The principle worked upon is to send a man whose home is, say, in the south, to do his service in the north, and vice versa, a man thus becoming familiar with as large a stretch of the frontier as possible. For example, a native of Nice will be sent to a Chasseur battalion at, say, Grenoble or Albertville. Thus, in the 6e *bataillon* there were a number of Alsatians.

Composition of a Battalion :—



Each battalion possesses one small gun (*canon de* 37) and one Stokes mortar.

Such importance is attached during the recruit's training to the "Groupe," which is the miniature fighting unit in the company, that it is worth while studying a detail of its composition.

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Composition of a "Groupe."

Composition.		*Arm.*
1 N.C.O. commanding the *Groupe*		Rifle
1 *équipe* of Light Machine-Gunners	1 "*caporal*" cmdg. *équipe*	Carbine
	1 Firer	M.G. and revolver
	1 Assistant	Revolver
	3 Spare men	Carbines
1 *équipe* of Bombers	1 "*caporal*" cmdg. *équipe*	Rifle
	1 Bomb-thrower	Carbine and revolver
	1 Rifle Bomber	Rifle
	3 Riflemen	Rifle

The training of the recruits, from the date of their joining-up, is on the following lines :—

(1) All the recruits are incorporated in the three ordinary companies and armed with the rifle. They receive individual instruction in the use of the rifle, close order infantry drill and preliminary musketry. Those men who possess a sufficient knowledge of the rifle at the time of their joining up begin firing a course at once, and the rest as soon after as possible.

(2) At the end of the first month, guided by the recommendations of the Company Commanders, the battalion commander details the men, who have been considered suitable, for the Machine Gun Company and for the Gun and Stokes mortar. These men begin a special training accordingly.

At the same time, each Company Commander picks out the men who look like making good N.C.O.'s and these are all collected together in a special platoon—one platoon per battalion—and begin a special training. The embryonic N.C.O.'s are called "élèves-caporaux" and at the end of four months they become, with good conduct, "caporaux," and after a further five months in another special platoon, they are eventually made N.C.O.'s with the rank of sergeant.

(3) During the third month each man is given a definite rôle in his "groupe," and section and company drill is carried out.

4) At the end of the fourth month the recruits are considered ready to take the field if required to do so.

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(5) From the beginning of the fifth month onwards the battalion carries out exercises as a unit and prepares itself for the annual manœuvres.

The command is exercised as follows :—

The Battalion Commander gets out a programme for the whole year and receives the recruits at the beginning of the fifth month trained ready for battalion exercises. During the first four months he hands the recruits over to the

Company Commanders, who get out a detailed programme for the four months and receive the recruits at the beginning of the fourth month ready trained for company drill. During the first three months he hands the men over to the

Subalterns, who are responsible that the recruits get a complete knowledge of *groupe* and *section* drill according to the programme of the company commander. They usually content themselves with supervision and hand on the executive work to the

N.C.O.'s, who carry out the actual training of the recruits for the first three months or so.

The following are the main items in the training of the soldier :—

1. The raising of his " moral."
2. Physical training.
3. Musketry, bombing and machine-gunnery.
4. Infantry Drill.
5. Knowledge and use of ground : use of tools and the gas-mask.
6. Recreation.
7. Signalling and specialist work generally.
8. Field exercises and manœuvres.

One of the chief points aimed at is that every soldier should be able to assume any rôle whatsoever, at a moment's notice, in the " groupe." This entails for each man an intimate knowledge of the light machine-gun, the bomb, the rifle-grenade, the rifle and the carbine, and the revolver.

INSTRUCTION OF OFFICERS.

The colonel of a regiment is responsible for the instruction of the officers under him. This instruction comprises :—

1. General instruction.
2. Professional instruction.

1. General instruction aims at ensuring the officer's prestige in the eyes of the N.C.O.'s and men. The following methods are employed :—

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(*a*) The institution of regimental libraries.
(*b*) Periodical conferences for regimental officers.
(*c*) Conferences for officers of the garrison.
(*d*) The grouping together of officers for common study and for carrying out definite exercises.

2. Professional instruction consists in :—
(*a*) Complete knowledge of Infantry Regulations (including M.G.'s and Tanks) : a working knowledge of other arms, especially Artillery and Air Force.
(*b*) Intimate acquaintance with the manipulation of all weapons used by the Infantry.
(*c*) Ability to command their own and higher units.
(*d*) Perfect knowledge of the neighbouring country by means of reconnaissances, map-reading, etc.

The professional instruction of officers is supervised closely by the Battalion Commander, who assembles his officers periodically, issues programmes of studies, and checks progress made. He reports confidentially, once a year at least, on each officer to the Regimental Commander.

Finally, all officers of dismounted units attend compulsory riding classes twice a week during six months of the year. These classes are held at the riding school of one of the cavalry or artillery units in the garrison.

Sapper Training.

One does not, perhaps, fully realise the difficulties the French have to contend with in training their sappers.

With a service of only 18 months, a raw recruit has to be turned out an efficient fighting-man as well as a technically trained engineer. Moreover, although the compulsory service is theoretically 18 months, yet, what with numerous exemptions on compassionate grounds, sickness, and special duties, the average recruit is lucky if he gets a full year's training.

The following shows briefly how the French sappers are organised on a war footing :—

(1) *Divisional Sappers.*
(*a*) A Commanding Officer (Lieut.-Colonel) and Staff.
(*b*) One Battalion of two Sapper and Miner Companies.
(*c*) One Park Company.

In addition a battalion of territorial Pioneers is nearly always available.

(2) *Corps Sappers.*
(*a*) A Commanding Officer (General or Colonel) and Staff.
(*b*) One Battalion of two Sapper and Miner Companies.
(*c*) One Bridging Company.

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(3) *Army Sappers.*

(*a*) A Commanding Officer (General) and Staff.

(*b*) A variable number of Sapper and Miner Companies, either regular or territorial.
Light Bridging Companies.
Heavy Bridging Companies.
Mining Companies.

(*c*) An Officer in command of Works, commanding the following :—
Road Companies.
Forest Companies.
I.W.T. Companies.
Companies of Electricians.
Camp Construction Companies.
Park Companies.

(4) *Organization of a Sapper and Miner Company.*

The Sapper and Miner Company constitutes the tactical unit. It deals with all works (including bridging), which do not require too great a specialised knowledge. It is the unit that finds itself most commonly in contact with the Infantry.

(*a*) Personnel—
5 Officers, including one Captain in Command.
24 N.C.O.'s.
251 Sappers.
33 Horses.
13 Vehicles.
The company is divided into one headquarters section and four sections of equal strength, and possesses a first and second line train.

(*b*) Equipment—The sappers are all armed with the carbine.

(*c*) First line tools :—
52 Picks. 52 Shovels. 32 Axes. 10 Bill-hooks. 8 Wire-cutters, etc.
The first line tools are similar to the tools kept in the Park, but are of a lighter pattern, to render them more portable.

(*d*) First line train comprises six vehicles, namely :—
4 Tool carts (one per section). 1 Bridging Waggon. 1 Explosives Waggon.

(*e*) The company park is its own particular property and serves nobody else but the company. The divisional park, on the contrary, keeps the troops of all arms supplied with tools.

The peace-time organisation of the French Sappers is somewhat different from the foregoing.

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THE EARLY DAYS OF M.T. AND SOME IDEAS ON ITS FUTURE.

By CAPTAIN A. MASON, M.C., R.E.

(Extracted from *Proceedings of the Royal Society of Arts* by kind permission of Col. R. E. B. Crompton, C.B.)

AN apology is due for the publication of such secondhand information as is contained in this article, compiled from two lectures delivered at an interval of 12 months to a Society whose proceedings are not widely known to Officers of the Corps. Mechanical Transport is of great importance to the Army at present, and it is hoped that the following summary may create interest both in its beginnings and in its possible developments.

The first lecture was delivered by Col. R. E. B. Crompton, who should need no introduction to readers of this Journal, and contained many personal reminiscences of the progress of the road vehicle after the introduction of steam traction engines. His interest in this apparently dated from his intimacy with Sir Frederick Bramwell, who had worked on the Hancock road engines about the year 1827, and, as a result of a visit to the Royal Agricultural Show at Leeds in 1861, where a traction engine was on view, Crompton " was " fired with the ambition to produce a steam-driven motor-car " for passengers which would travel at a reasonable speed."

This car, presumably one of many which firms and private individuals were experimenting with in various parts of the world, ran on wooden wheels and iron tyres, and was on the road in 1863, having been taken out to India by its designer and completed there, and achieving a speed of 20 miles an hour.

Crompton, however, at this time, heard of the work of R. W. Thomson, a prolific inventor, one of whose earliest patents, taken out in 1845, was for the use of " india-rubber " for the tyres of vehicles. For some years this patent led to nothing, but in 1867 Thomson produced a steam-tractor for road work, the wheels of which consisted of double-flanged W.I. drums, about 4-ft in diameter and 13-in. wide, in between the flanges of which lay flat india-rubber bands about 4½-in. thick and 12-in. wide. This tractor successfully towed a large trailer at 12 miles an hour, and Crompton, seeing a report of the tests in the papers of the day,

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got into touch with Thomson and eventually persuaded the Government of India to try the Thomson engine on the bullock train system which supplemented the then unfinished railways.

Accordingly a department was formed, called the Government Steam Train. Crompton was appointed the first superintendent, and a trial engine was ordered from Thomson. This arrived in due course, and after assembly in the Government workshops at Aligarh, was tried on the run from Amballa to Kalka in 1869. However, having a firebox designed for coal, and wood fuel being all that was available, it "had to stop so frequently to raise steam "that its speed was not much greater than that of the bullock-train "that it was meant to supersede." In other respects it was satisfactory, and the Viceroy was persuaded to continue the experiment and to order four steam trains of improved design, complete with wagons and passenger vehicles: as at this time Crompton's health gave way, he was ordered home to supervise the carrying out of the order.

The first new engine, the "*Chenab*," with wheels 6ft. 6ins. in diameter and rubber tyres 15in. wide and 4½ to 5in. thick, was fitted with a new "*pot*" boiler designed by Thomson, which was still, in Crompton's opinion, unsuitable for wood fuel. Actually it was found necessary, in order to maintain steam, to increase the draught to such an extent that the chimney spouted sparks, and, during one of its early trials in 1871 it "set fire to the grand "stand on the Ipswich race-course, and the Government of India "had to pay for a new one."

The second engine, the "*Ravee*," was, therefore, ordered to be fitted with the Field type of boiler then used by Merryweathers on steam fire-engines. In the meantime the makers of the *Chenab*, Messrs. Ransomes, Sims and Head, of Ipswich, were sufficiently pleased with it to wish to exhibit it at the Royal Agricultural Society's Show at Wolverhampton in the summer.

The run by road from Ipswich to Wolverhampton, nicknamed "Lieutenant Crompton's honeymoon trip," occupied eight days and was not a great success: the boiler was troublesome, and it was fortunate that the crew included two boiler-makers, for the boiler-tubes had to be expanded every night. The total crew numbered about 15 persons, including two married couples. This train was a five-wheeled affair, for *Chenab* had three wheels and the trailer was a two-wheeled rubber-tyred omnibus, designed to carry 130 people, 60 below and 70 above. It is hardly surprising therefore that its passage across England created some sensation. The lower deck of the omnibus gave ample sleeping accommodation for the crew of fifteen.

At Wolverhampton it was possible to compare the rubber-tyred *Chenab* with the ordinary steel-tyred agricultural engine. The

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makers of the latter appear to have been unfriendly to the newcomer and to have blamed the tyres for breakdowns, which were generally the fault of the boiler. It was found, as might be expected, that, for ploughing, the rubber tyres were an advantage in dry weather, but, in wet, non-skid chains were necessary. The omnibus was offered to the judges of the Show as an office and *Chenab* was lent to tow them round. A request for an exhibition of manœuvring was readily granted by Crompton, who was driving, and he eventually achieved "figures of eight at nearly 20 miles per hour"; the sway of the 'bus on its thick soft rubber tyres was, however, enough to make many of the judges sea-sick.

Chenab was eventually sent home by train in disgrace, and *Ravee*, ready in August, 1871, was taken out on trial. The Field boiler worked satisfactorily with wood fuel, and it was decided to run from Ipswich to Edinburgh and back, so that Thomson, who lived in Edinburgh as an invalid, could see the train. The same omnibus was taken as a trailer, but through the influence of the Government of India the limit of speed of four miles per hour under the Red Flag Act was not enforced, and a maximum of more than 25 miles an hour was achieved.

There was very little trouble with horses on the road; they stared at the engine, but were not greatly frightened, owing to the lack of any noise. The attitude of human spectators was, however, more varied. A certain amount of night running was done, and at one place the toll-gateman, who had closed and locked his gate for the night, refused to open it and let the train through. Crompton, in righteous indignation and in the satisfactory position of being on duty, gently opened the throttle, *Ravee* gently pressed against the gate, the gate flipped away into the adjoining field, and the train went on its way.

The run was entirely satisfactory; the distance was 424 miles, which was covered in 77 and 61¼ hours running time, going and returning respectively: on the last day of the return journey the average speed was about 10 miles per hour. Where the Great North Road ran parallel to the Great Northern Railway, the road train overtook and passed several goods trains travelling in the same direction.

At Edinburgh adhesion tests were carried out which gave a co-efficient of adhesion of 60 per cent. of weight on the driving wheel, a figure considerably in excess of that obtainable without rubber tyres. For wet weather the non-skid chains were replaced by clip shoes, which suffered less wear; in dry weather the running was on bare rubber, which, being prevented by the flanges from expanding sideways, had to expand in the direction of its length, the result being that the tyres "rolled out in front of the driving "wheels and actually left the polished steel treads, so that the

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" engine practically ran on the upper (inner ?) surface of a con-
" tinuous track resembling the modern caterpillar track." This was not objectionable and friction on the inner side of the tyre was afterwards " taken up by transverse metal rods covered with " anti-friction metal." The train, being thus insulated by rubber from earth, acquired a high static electric charge which had to be dissipated by trailing a wire along the ground behind.

Crompton left for India in the autumn, and, being ordered to work the trains on the Grand Trunk road from Rawal Pindi to Attock (70 miles), spent the spring of 1872 in preliminary work. Two trains were running by the next autumn, but both engines broke their crankshafts within two months. " At that time " it was thought that as the driving wheels could slip, to a certain " extent inside their tyres, a differential gear was unnecessary, " but this view proved to be mistaken, for although this slip, un-" doubtedly, did take place and was sufficient to allow of accurate " steering round curves of great radius, on curves of small radius " the drivers were instructed to throw out of gear the wheel on " the inner side of the curve, but the drivers did not always obey " orders, and undoubtedly this was the cause of the crankshaft " failures." Differential gearing was designed by Mr. Monteith, of the Post Office (identical in every way with that fitted to the Super-Sentinel steam waggon, 1923), but owing to inadequate workshops could not then be carried out, and, instead, an alteration of gearing enabled the torsion strains to be shifted from the crank-shaft to the countershaft.

During the winter of 1873 the trains were employed on manœuvres at Hassan Abdal with great success, and Lord Roberts, who was present, afterwards admitted that his subsequent belief in the value of mechanical transport originated with the excellent work done that winter by the steam trains..

At this time a Government Committee of Inquiry under the Chairmanship of Col. Hyde, R.E., with another R.E. Officer as a member, was investigating the progress and value of the road trains. The trains tested consisted of 19 vehicles of a gross load of about 70 tons and a paying load of 40 tons. The " wag of the tail " of such a procession was somewhat dangerous until eliminated by careful proportioning of coupling lengths.

The report of the Committee was very favourable, but the spread of railways of various gauges eventually rendered the road trains superfluous and they were handed over to the railway authorities about 1878.

During the progress of this interesting experiment a good many modern transport problems had to be faced and all were overcome with the exception of " side-slip."

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II.

Colonel Crompton has seen such great strides made in methods of transport and has been personally involved in so many of them that his views on the future are of great value. It is of interest to compare them with the suggestions of Sir Alan Burgoyne, who delivered the second lecture referred to.

The latter confined himself to developments in the internal combustion engine. In the line of engine design, he prophecies the disappearance of the magneto, the poppet valve, and all drive by belts; the modification of the carburettor towards the elimination of jets; and the introduction of a super charger or "booster." This device, which is little known in this country outside technical circles, would undoubtedly be too much for the motor engine in its present form, but there seems no reason why the design should not be strengthened to stand it, and, once it has been applied, the main advantage of steam engines over I.C. engines—their reserve power—should largely be overtaken.

The extra power of the supercharger, utilized on gradients and backed by more powerful engines, should render gears eventually unnecessary; in the meantime gear changing by present methods may be replaced fairly soon by infinitely variable mechanism which may later become automatically actuated.

The possibility of the application of hydraulic action to gear and drive is an interesting speculation: four-wheel drive is already desirable under some circumstances, and the abolition of water cooling under others.

Col. Crompton, on the other hand, is a keen electrical man and hopes for a great future for the electrical vehicle. He believes that "the use of a rapidly reciprocating internal combustion engine "is not conducive to noiselessness, to economy or to low cost "of upkeep" and looks forward to its eventual supersession by a new engine on the lines of the gas turbine. Presumably in his mind the drawbacks of the I.C. engine apply to the Petrol-Electric type and, therefore, his electric vehicle will be either accumulator driven or else an entirely new development. Until accumulators can be reduced very greatly in weight, the economic use of vehicles driven by them is limited to those of heavy load and low speed, when they compete more with the road steamer.

The present difficulty with the gas turbine appears to be that of obtaining reasonable efficiency with the smaller types, say of less than 1,000 h.p.; but, in view of the fact that French designers have succeeded in getting high efficiency from turbines driven by the exhaust gases of an I.C. engine, it does not seem that the further development necessary to produce the gas turbine need be long delayed.

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Two rather longer shots into the future were made, viz. : "The "direct production of electricity by the consumption of fuel, and, "secondly, the direct conversion, possibly through the thermionic "valve of wireless telephony, of those electro-magnetic waves "of energy which reach the earth from the sun."

One or two gaps are left in this picture of the future. Steering arrangements at present can hardly be termed perfect. The present lorry body leaves a great deal to be desired : the tendency is for the chassis to become more flexible ; but, if the torsion in the springing is to be limited, the body must follow. For general utility long bodies there is a limit beyond which flexibility cannot go, and this will probably require new methods of suspension and shock-absorption, allowing easy, controlled, motion in three dimensions.

Neither speaker mentions the future of tyres or tracks. To have to pump up a tyre is in these days an anachronism as well as a nuisance, and substitutes for pneumatics for light as well as heavy vehicles are to be expected. For the heavy vehicle, modification of the track system may go a long way, and Col. Crompton with his early experience should take considerable interest in the track vehicles recently placed on the Swiss roads for heavy snow-work, where the drive is from rubber-tyred wheels, through rubber cogging to a rubber track.

Even if, in 100 years' time, the world may be dry of petrol, rubber will probably be in even greater use, for supply is expected to keep ahead of demand after five or ten years.

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BATTLE HONOURS OF ROYAL ENGINEERS UNITS.

BATTLE HONOURS OF ROYAL ENGINEER UNITS.

ADDITIONS AND CORRECTIONS.

The last day of the Battle of the Aisne is 12th *October*, and not as previously published. The following is a corrected list for this Battle and should replace that published on pp. 240 and 241 of the June 1925 *R.E. Journal*.

AISNE, 1914. 12TH SEPTEMBER—12TH OCTOBER, 1914.

Unit.	Formation.		
CAVALRY CORPS.			
1st Field Sqn.	1st Cav. Div.	E.	
4th Field Troop.	2nd ,,	,,	Absorbed in 2nd Field Sqn. 15th Oct.
I ARMY CORPS.			
23rd Field Co.	1st Div.	E.	
26th ,,	,,	,,	
5th Field Co.	2nd Div.	,,	
11th ,,	,,	,,	
II ARMY CORPS.			
56th Field Co.	3rd Div.	E.	
57th ,,	,,	,,	
17th Field Co.	5th Div.	,,	
59th ,,	,,	,,	
III ARMY CORPS.			
7th Field Co.	4th Div.	E.	
9th ,,	,,	,,	
12th Field Co.	6th Div.	,,	
38th ,,	,,	,,	
ARMY TROOPS.			
1st Bridging Train	I & II Corps.	E.	
2nd ,,	III Corps.	,,	
20th Fortress Co.	I Corps.	,,	Attached 2nd Div.
42nd ,,	II Corps.	,,	Attached 3rd Div.
	SIGNALS.		
Cavalry Corps Signal Sqn.	Cavalry Corps.	N.E.	
1st Signal Sqn.	1st Cav. Div.	E.	
2nd Signal Sqn.	2nd ,,	D.	No diary.
I Army Corps Signal Co.	I Army Corps	E.	
1st Divl. Signal Co.	,, ,,	,,	
2nd ,, ,, ,,	,, ,,	,,	
II Army Corps Signal Co.	II Army Corps	,,	
3rd Divl. Signal Co.	,, ,,	,,	
5th ,, ,, ,,	,, ,,	,,	
III Army Corps Signal	III Army Corps	,,	
4th Divl. Signal Co.	,, ,,	,,	
6th ,, ,, ,,	,, ,,	,,	

On page 89 of March 1926, *Journal*, the 1st. Field Sqdn. belonged to I *Cavalry* Division, not *Canadian*.

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Two rather longer shots into the future were made, viz. : "The "direct production of electricity by the consumption of fuel, and, "secondly, the direct conversion, possibly through the thermionic

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BATTLE HONOURS OF ROYAL ENGINEERS UNITS.

(*Continued.*)

BAPAUME, 1917. 17TH MARCH, 1917.

Unit.	Formation.		Remarks.
FIFTH ARMY.			
I ANZAC CORPS.			
5th Australian Fd. Co.	2nd Aust. Divn.	D.	
6th ,,	,,	E.	
7th ,,	,,	,,	
8th ,,	5th Aust. Divn.	D.	
2nd Aust. Divl. Sig. Co.	2nd Aust. Divn.	,,	
II CORPS.			
5th Field Co.	2nd Divn.	N.E.	In attack on Irles, 10th March.
226th ,,	,,	,,	In attack on Irles 10th March.
79th ,,	18th Divn.	,,	In attack on Irles 10th March.
80th ,,	,,	,,	In attack on Irles 10th March.
92nd ,,	,,	,,	In attack on Irles 10th March.

NOTE.—No fighting took place on the 17th March.
No other R.E. unit can be traced as within the area.
No Labour Battalion was within the area.

N.B.—"ARRAS, 1917" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM "VIMY" TO "HILL 70."

VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
No. 2 Special Co.	Special Bde. G.H.Q.	E.	
No. 4 ,,	,,	,,	
D ,,	,,	,,	
F ,,	,,	,,	
M ,,	,,	,,	
No. 4 Advanced R.E. Park	1st Army.	D.	No diary.
No. 8 ,,	,,	,,	No diary.
25th Army Troops Co.		N.E.	
31st ,,	I Corps.	,,	
134th ,,		,,	
215th ,,	I Corps.	,,	
285th ,,		D.	No diary.
552nd (Aberdeen) Army Troops Co.	XI Corps.	N.E.	
556th (Glamorgan) Army Troops Co.	,,	,,	
560th (Hants.) Army Troops Co.	I Corps.	,,	
1st Canadian Army Troops Co.	Canadian Corps.	E.	
2nd Canadian Army Troops Co.	,,	N.E.	
3rd Canadian Troops Troops Co.	,,	E.	
4th Canadian Army Troops Co.	,,	,,	

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VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
170th Tunnelling Co.	XI & I Corps.	N.E.	
172nd ,,	Canadian Corps.	E.	
173rd ,,	I Corps.	,,	
176th ,,	Canadian Corps.	,,	
182nd ,,	,,	,,	
185th ,,	,,	,,	
251st ,,	XI Corps.	N.E.	
253rd ,,	I Corps.	,,	
254th ,,		,,	
255th ,,	Canadian Corps.	D.	No diary.
257th ,,		N.E.	
3rd Australian Tunnelling Co.	I Corps.	,,	
197th Land Drainage Co.		D.	No diary.
350th Elect. & Mech. Co.		,,	No diary.
1st Field Survey Co.		,,	No diary.
2nd Forestry Dett.		,,	No diary.
No. 1 Pontoon Park	XI Corps.	N.E.	
I CORPS.			
103rd Field Co.	24th Divn.	N.E.	
104th ,,	,,	D.	
129th ,,	,,	E.	
223rd ,,	31st Divn.	N.E.	
CANADIAN CORPS.			
59th Field Co.	5th Divn.	E.	
491st (Home Counties) Field Co.	,,	,,	
527th (Durham) Field Co.	,,	,,	
1st Canadian Field Co.	1st Can. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th Canadian Field Co.	2nd Can. Divn.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th Canadian Field Co.	3rd Can. Divn.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
10th Canadian Field Co.	4th Can. Divn.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	

SIGNALS.

VIMY, 1917. 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
A Army Corps Signal Co.	I Corps.	N.E.	
24th Divl. Signal Co.	,,	,,	
Canadian Army Corps Signal Co.	Canadian Corps.	D.	
5th Divl. Signal Co.	,,	E.	
1st. Can. Divl. Sig. Co	,,	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
25th Army Troops Co.	XIII Corps.	N.E.	
230th ,,		E.	
185th Tunnelling Co.	Canadian Corps.	D.	

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SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
THIRD ARMY.			
No. 1 Special Co. Sects. A. & B.	Special Bde.	E.	
No. 3 ,,	,,	,,	
J ,,	,,	,,	
O ,,	,,	,,	
Q ,,	,,	,,	
Z ,,	,,	,,	
No. 5 Advanced R.E. Park		D.	No diary.
No. 8 ,,		,,	No diary.
No. 12 ,,		,,	No diary.
178th Railway Co.		N.E.	
42nd Army Troops Co.	VI Corps.	E.	
132nd ,,	VII ,,	D.	
133rd ,,	VI ,,	E.	
141st ,,	XVIII ,,	N.E.	
144th ,,		D.	No diary.
145th ,,	VII ,,	N.E.	
146th ,,	VI ,,	E.	
147th ,,	VII ,,	N.E.	
221st ,,	XVII ,,	E.	
235th ,,	VII ,,	,,	
236th ,,		D.	No diary.
280th ,,	XVII ,,	E.	
283rd ,,	XVII ,,	D.	
288th ,,	VII ,,	E.	
289th ,,	XVII ,,	,,	
557th (Glamorgan) Army Troops Co.	VI ,,	N.E.	
179th Tunnelling Co.	VI ,,	E.	
181st ,,		N.E.	
184th ,,	XVII ,,	E.	
New Zealand Tunnelling Co.	VI ,,	,,	
352nd Elec. & Mech Co.		,,	
3rd Field Survey Co.		D.	No diary.
No. 3 Pontoon Park	VI & XVII Corps.	E.	
No. 3 Labour Bn. R.E.		N.E.	
No 1 Army Tramway Co.	XVII Corps.	,,	
No. 4 ,,	VI ,,	,,	
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	,,	
483rd (East Anglian) Field Co.	,,	,,	
207th Field Co.	34th Divn.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
THIRD ARMY, CAVALRY CORPS.			
1st Field Squadron	1st Cav. Divn.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (East Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
73rd ,,	15th Divn.	,,	
74th ,,	,,	,,	
91st ,,	,,	,,	

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SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation		Remarks.
VI CORPS.			
77th ,,	17th Divn.	E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	
455th (W. Riding) Fld. Co.	29th Divn.	,,	
497th (Kent) Fld. Co.	,,	,,	
510th London) ,,	,,	,,	
152nd Field Co.	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
VII CORPS.			
61st Field Co.	14th Divn.	E.	
62nd ,,	,,	,,	
89th ,,	,,	,,	
97th Field Co.	21st Divn.	,,	
98th ,,	,,	N.E.	
126th ,,	,,	E.	
504th ,,	58th Divn.	N.E.	Attached 21st Divn.
200th Field Co.	30th Divn.	E.	
201st ,,	,,	,,	
202nd ,,	,,	,,	
11th Field Co.	33rd Divn.	,,	
212th ,,	,,	,,	
222nd ,,	,,	N.E.	
7th Field Co.	50th Divn.	E.	
446th (Northn.) Fld. Co.	,,	,,	
447th ,,	,,	,,	
416th (Edinburgh) Fld. Co.	56th Divn.	,,	
512th (London) Fld. Co.	,,	,,	
513th ,,	,,	,,	
XVII CORPS.			
9th Field Co.	4th Divn.	E.	
526th (Durham) Field Co.	,,	,,	
406th (Renfrew) ,,	,,	,,	
63rd Field Co.	9th Divn.	,,	
64th ,,	,,	,,	
90th ,,	,,	,,	
400th (Highland) Fld. Co.	51st Divn.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
34th ,,	34th ,,	,,	
Third Army Signal Co.		N.E.	
Cavalry Corps Signal Co.	Cavalry Corps	E.	
1st Signal Squadron	1st Cav. Divn.	,,	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	,,	
F Corps Signal Co.	VI Corps.	D.	
3rd Divl. Signal Co.	3rd Divn.	E.	No diary.
12th ,,	12th ,,	,,	
15th ,,	15th ,,	,,	
17th ,,	17th ,,	,,	
29th ,,	29th ,,	,,	
37th ,,	37th ,,	,,	
C Corps Signal Co.	VII Corps.	D.	

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SCARPE, 1917 (FIRST BATTLE). 9TH-14TH APRIL, 1917.

Unit.	Formation.	Remarks.
14th Divl. Signal Co.	14th Divn.	E.
21st ,,	21st ,,	,,
30th ,,	30th ,,	,,
33rd ,,	33rd ,,	,,
50th ,,	50th ,,	,,
56th ,,	56th ,,	,,
R Corps Signal Co.	XVII Corps.	D.
4th Divl. Signal Co.	4th Divn.	E.
9th ,,	9th ,,	,,
51st ,,	51st ,,	,,

SCARPE, 1917 (SECOND BATTLE). 23RD-24TH APRIL, 1917.

Unit.	Formation.	Remarks.
THIRD ARMY.		
No. 3 Special Co.	Special Bde.	E.
J ,,	,,	,,
O ,,	,,	,,
Q ,,	,,	,,
178th Railway Co.		,,
25th Army Troops Co.	XIII Corps.	,,
42nd ,,	VI ,,	,,
132nd ,,	VII ,,	,,
133rd ,,	VI ,,	,,
145th ,,	VII ,,	,,
146th ,,	VI ,,	,,
221st ,,	XVII ,,	,,
230th ,,	XIII ,,	D.
235th ,,	VII ,,	E.
280th ,,	XVII ,,	,,
283rd ,,	XVII ,,	N.E.
288th ,,	VII ,,	E.
289th ,,	XVII ,,	,,
179th Tunnelling Co	VI ,,	D.
181st ,,		E.
184th ,,	XVII Corps.	,,
New Zealand Tunnelling Co.	VI ,,	,,
352nd Elec. & Mech Co.		,,
No. 3 Pontoon Park	VI & XVII Corps.	E.
No. 1 Army Tramway Co.		D.
No. 4 ,,	VI Corps.	E.
FIRST ARMY, XII CORPS.		
247th Field Co.	63rd (R.E.) Div.	N.E.
248th ,,	,,	E.
249th ,,	,,	,,
THIRD ARMY, VI CORPS.		
73rd Field Co.	15th Divn.	,,
74th ,,	,,	,,
91st ,,	,,	,,
77th ,,	17th Divn.	,,
78th ,,	,,	,,
93rd ,,	,,	,,
455th (W. Riding) Fld. Co.	29th Divn.	,,
497th (Kent) Fld. Co.	,,	,,
510th (London) ,,	,,	,,
56th Field Co.	3rd Divn.	,,
438th (Cheshire) Fld. Co.	,,	,,
529th (East Riding) ,,	,,	,,
VII CORPS.		
200th Field Co.	30th Divn.	E.
201st ,,	,,	,,
202nd ,,	,,	,,

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SCARPE, 1917 (SECOND BATTLE). 23RD-24TH APRIL, 1917.

Unit.	Formation.		Remarks.
VII CORPS.			
11th Field Co.	33rd Divn.	E.	
212th ,,	,,	,,	
222nd ,,	,,	,,	
7th ,,	50th Divn.	,,	
446th (Northn.) Fld. Co.	,,	,,	
447th ,,	,,	,,	
XVII CORPS.			
152nd Field Co.	37th Divn.	E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
400th (High.) Field Co.	51st Divn.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
207th Field Co.	34th Divn.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (SECOND BATTLE). 23RD-24TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps.	D.	
63rd Divl. Signal Co.	63rd Divn.	E.	
Third Army Signal Co.		N.E.	
F Corps Signal Co.	VI Corps.	D.	
15th Divl. Signal Co.	15th Divn.	E.	
17th ,,	17th ,,	,,	
29th ,,	29th ,,	,,	
3rd ,,	3rd ,,	D.	Diary missing.
G Corps Signal Co.	VII Corps.	,,	,,
30th Divl. Signal Co.	30th Divn.	E.	
33rd ,,	33rd ,,	,,	,,
50th ,,	50th ,,	,,	
R Corps Signal Co.	XVII Corps.	D.	
37th Divl. Signal Co.	37th Divn.	E.	
51st ,,	51st ,,	,,	
34th ,,	34th ,,	D.	

ARLEUX. 28TH-29TH APRIL, 1917.

Unit.	Formation.		Remarks.
FIRST AND THIRD ARMIES.			
No. 3 Special Co.	Special Bde.	E.	
O ,,	,,	,,	
Q ,,	,,	,,	
178th Railway Co.		D.	
261st ,,	XIII Corps.	N.E.	
25th Army Troops Co.	XIII ,,	E.	
42nd ,,	VI ,,	,,	
133rd ,,	VI ,,	,,	
146th ,,	VI ,,	,,	
221st ,,	XVII ,,	,,	
230th ,,	XIII ,,	,,	
280th ,,	XVII ,,	,,	
283rd ,,	XVII ,,	N.E.	
289th ,,	XVII ,,	E.	
176th Tunnelling Co.	Canadian ,,	D.	
79th ,,	VI ,,	E.	
184th ,,	XVII ,,	,,	
185th ,,	Can. ,,	N.E.	
New Zealand Tunnelling Co.	VI ,,	E.	
No. 3 Pontoon Park	VI & XVII Corps.	,,	
No. 1 Army Tramway Co.		,,	
No. 4 ,,	VI Corps.	,,	

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ARLEUX, 28TH-29TH APRIL, 1917.

Unit.	Formation		Remarks.
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	,,	
483rd (East Anglian) Field Co.	,,	,,	
274th Field Co.	63rd (R.N.) Divn.	,,	
248th ,,	,,	D.	
249th ,,	,,	E.	
CANADIAN CORPS.			
1st Canadian Field Co.	1st Can. Divn.	E.	
2nd ,,	,,	D.	
3rd ,,	,,	N.E.	
4th ,,	2nd Can. Divn.	D.	
5th ,,	,,	E.	
6th ,,	,,	,,	
THIRD ARMY, VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (E. Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	D.	
XVII CORPS.			
207th Field Co.	34th Divn.	E.	
208th ,,	,,	,,	
209th ,,	,,	,,	
152nd ,,	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
400th (High.) Field Co.	51st Divn.	N.E.	
401st ,,	,,	E.	
404th ,,	,,	,,	

SIGNALS.

ARLEUX. 28TH-29TH APRIL, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.		N.E.	
N Corps Signal Co.	XIII Corps.	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
63rd ,,	63rd (R.N.) Div.	,,	
Canadian Corps Sig. Co.	Can. Corps.	N.E.	
1st Can. Divl Sig. Co.	1st Can. Divn.	E.	
2nd ,,	2nd ,,	,,	
Third Army Signal Co.		N.E.	
F Corps. Signal Co.	VI Corps.	D.	
3rd Divl. Signal Co.	3rd Divn.	E.	
12th ,,	12th Divn.	,,	
R Corps Signal Co.	XVII Corps.	D.	
34th Divl. Signal Co.	34th Divn.	E.	
37th ,,	37th Divn.	,,	

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
No. 4 Advanced R.E. Park		D.	No diary.
20th Army Troops Co.	XIII Corps.	E.	
25th ,,	,,	,,	
31st Army Troops Co.		N.E.	
215th ,,		,,	
230th ,,	XIII Corps.	,,	
285th ,,		D.	No diary.
560th (Hants.) Army Troops Co.		N.E.	

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SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.	E.	Remarks.
FIRST ARMY.			
1st Can. Army Troops Co.	Can. Corps.	N.E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	
170th Tunnelling Co.		,,	
172nd ,,	Can. Corps.	,,	
176th ,,	XIII Corps.	E.	
182nd ,,	Can. Corps.	N.E.	
185th ,,		,,	
253rd ,,		,,	
255th ,,	Can. Corps.	,,	
261st Railway Co.	XIII Corps.	,,	
350th Elect. & Mech Co.		,,	
1st Field Survey Co.		D.	No diary.
No. 1 Pontoon Park		,,	No diary.
No. 7 Army Tramway Co.		,,	No diary.
FIRST ARMY, XIII CORPS.			
5th Field Co.	2nd Divn.	E.	
226th ,,	,,	D.	
483rd (East Anglian) Field Co.	,,	N.E.	
59th Field Co.	5th Divn.	,,	
491st (Home Counties) Field Co.	,,	E.	
527th (Durham) Fld. Co.	,,	D.	
210th Field Co.	31st Divn.	E.	
211th ,,	,,	,,	
223rd ,,	,,	,,	
247th ,,	63rd (R.N.) Div.	N.E.	Under C.E. XIII Corps.
248th ,,	,,	,,	,,
249th ,,	,,	D.	Under C.R.E. 31st Div.
CANADIAN CORPS.			
1st Canadian Field Co.	1st Can. Divn.	N.E.	
2nd ,,	,,	E.	
3rd ,,	,,	D.	No diary.
4th ,,	2nd Can. Divn.	E.	
5th ,,	,,	,,	
6th ,,	,,	,,	
7th ,,	3rd Can. Divn.	N.E.	
8th ,,	,,	,,	No diary.
9th ,,	,,	,,	
THIRD ARMY.			
O Special (Cylinder) Co.	Special Bde.	E.	
O ,,	,,	,,	
No. 3 Special (Mortar) Co.	,,	,,	
J Special (Cylinder) Co.	,,	D.	
No. 5 Advanced R.E. Park		,,	No diary.
No. 8 Advanced R.E. Park		,,	No diary.
No. 12 Advanced R.E. Park		,,	No diary.
42nd Army Troops Co.		N.E.	
132nd ,,	VII Corps.	,,	
133rd ,,		,,	
144th Army Troops Co.		D.	No diary.
145th ,,	VII Corps.	E.	
146th ,,		N.E.	
147th ,,		E.	
221st ,,	XVII Corps.	,,	
235th ,,	VII ,,	,,	
236th ,,	XVII ,,	N.E.	

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SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
THIRD ARMY			
280th Army Troops Co.	XVII Corps.	E.	
288th ,,	VII ,,	,,	
289th ,,	XVII ,,	,,	
557th (Glamorgan) Army Troops Co.	VI ,,	N.E.	
179th Tunnelling Co.		E.	
181st ,,	VII Corps.	,,	
184th ,,	XVII ,,	,,	
New Zealand Tunnelling Co.		,,	
352nd Elec. & Mech. Co.	VII Corps.	N.E.	No diary.
3rd Field Survey Co.		D.	No diary.
No. 3 Pontoon Park		N.E.	
No. 3 Labour Bn. R.E.	VII & XVII Corps.	,,	
No 1 Army Tramway Co.	XVII Corps.	D.	
No. 3 ,,	VI ,,	N.E.	
No. 5 ,,		D.	No diary.
VI CORPS.			
56th Field Co.	3rd Divn.	E.	
438th (Cheshire) Fld. Co.	,,	,,	
529th (E. Riding) ,,	,,	,,	
69th Field Co.	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
416th (Edinburgh) Fld. Co.	56th Divn.	,,	
512th (London) Fld. Co.	,,	,,	
513th ,,	,,	N.E.	
VII CORPS.			
61st Field Co.	14th Divn.	E.	
62nd ,,	,,	,,	
89th ,,	,,	,,	
79th ,,	18th Divn.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
97th ,,	21st Divn.	,,	
98th ,,	,,	,,	
126th ,,	,,	N.E.	
XVII CORPS.			
9th Field Co.	4th Divn.	E.	
526th (Durham) Fld. Co.	,,	,,	
406th (Renfrew) ,,	,,	,,	
63rd Field Co.	9th Divn.	,,	
64th ,,	,,	,,	
90th ,,	,,	,,	
77th ,,	17th Divn.	N.E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	

SIGNALS.

SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
First Army Signal Co.	First Army	N.E.	
N Corps Signal Co.	XIII Corps	D.	
2nd Divl. Signal Co.	2nd Divn.	E.	
5th ,,	5th ,,	D.	
31st ,,	31st ,,	E.	
Canadian A.C. Sig. Co.	Can. Corps	D.	
1st Can. Divl. Sig. Co.	1st Can. Divn.	E.	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	D.	
Third Army Signal Co.	Third Army	N.E.	

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SCARPE, 1917 (THIRD BATTLE). 3RD-4TH MAY, 1917.

Unit.	Formation.		Remarks.
F Corps Signal Co.	VI Corps	N.E.	
3rd Divl. Signal Co.	3rd Divn.	E.	
12th ,,	12th ,,	,,	
56th ,,	56th ,,	,,	
G Corps Signal Co.	VII Corps	D.	
14th Divl. Signal Corps	14th Divn.	E.	
18th ,,	18th ,,	,,	
21st ,,	21st ,,	,,	
R. Corps Signal Co.	XVII Corps	D.	
4th Divl. Signal Co.	4th Divn.	E.	
9th ,,	9th ,,	,,	
17th ,,	17th ,,	D.	

OPPY, 28TH JUNE, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
XIII CORPS.			
59th Field Co.	5th Divn.	E.	
491st (Home Counties) Field Co.	,,	N.E.	
527th (Durham) Fld. Co.	,,	E.	
210th Field Co.	31st Divn.	,,	
211th ,,	,,	,,	
223rd ,,	,,	,,	

SIGNALS.
OPPY. 28TH JUNE, 1917.

Unit.	Formation.		Remarks.
N Corps Signal Co.	XIII Corps	N.E.	
5th Divl. Signal Co.	5th Divn.	E.	
31st ,,	31st ,,	,,	

BULLECOURT. 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
FIFTH ARMY.			
No. 7 Advanced R.E. Park		N.E.	No diary.
138th Army Troops Co.	1 Anzac Corps	,,	
148th ,,		,,	
149th ,,		,,	
559th (Hants) Troops Co.	V Corps	,,	
567th (Devon) ,,		,,	
577th (Sussex) ,,		,,	No diary.
No 2 Siege Co. R. Anglesey	1 Anzac Corps	,,	
No. 1 Siege Co. R. Monmouth	V Corps	,,	
174th Tunnelling Co.	,,	E.	
252nd ,,	,,	N.E.	
258th ,,	1 Anzac Corps	E.	
354th Elec. & Mech. Co		N.E.	
5th Field Survey Co.		,,	
No. 7 Pontoon Park	1 Anzac Corps	,,	
No. 2 Labour Bn. R.E.		,,	
No. 6 ,,		,,	
No. 9 ,,		,,	
No. 11 ,,		,,	
V CORPS.			
54th Field Co.	7th Divn.	E.	
95th ,,	,,	,,	
528th (Durham) Field Co.	,,	,,	
503rd (Wessex) Fld. Co.	58th Divn.	,,	
504th ,, ,,	,,	,,	
511th (London) ,,	,,	,,	
457th (W. Riding) ,,	62nd Divn.	D.	

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BULLECOURT. 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
V CORPS.			
460th (W. Riding) Fld. Co.	62nd Divn.	D	
461st ,, ,,	,,	E.	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust. Div.	N.E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Div.	E.	
6th ,,	,,	,,	
7th ,,	,,	,,	
8th ,,	5th Aust. Div.	D.	
14th ,,	,,	E.	
15th ,,	,,	,,	

SIGNALS.
BULLECOURT, 3RD-17TH MAY, 1917.

Unit.	Formation.		Remarks.
Fifth Army Signal Co.	5th Army	N.E.	
O Corps Signal Co.	V Corps	,,	
7th Divl. Signal Co.	7th Divn.	E.	
58th ,,	58th ,,	,,	
62nd ,,	62nd ,,	,,	
K Corps Signal Co.	1 Anzac Corps	N.E.	
1st Aust. Div. Signal Co.	1st Aust. Div.	D.	
2nd ,,	2nd ,,	E.	
5th ,,	5th ,,	,,	

HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.		Remarks.
FIRST ARMY.			
B Special (Cylinder) Co.	Special Bde.	E.	
O ,,	,,	,,	
No 4 Special (Mortar) Co.	,,	,,	
No. 1 Advanced R.E. Park.		D.	No diary.
No. 4 Advanced R.E. Park		,,	No diary.
25th Army Troops Co.	XIII Corps	N.E.	
31st ,,	I Corps	,,	
215th ,,		,,	
230th ,,	XIII Corps	,,	
560th (Hants) Army Troops Co.		,,	
1st Can. Army Troops Co.	Can. Corps	,,	
2nd ,,	,,	,,	
3rd ,,	,,	E.	
4th ,,	,,	N.E.	
5th ,,	,,	,,	
170th Tunnelling Co.	I Corps	,,	
172nd ,,	Can. Corps	E.	
176th ,,	XIII Corps	N.E.	
182nd ,,	Can. Corps	D.	
185th ,,		N.E.	
3rd Aust. ,,	Can. Corps	E.	
196th Land Drainage Co.		N.E.	No diary.
350th Elec. & Mech. Co.		,,	No diary.
No. 1 Field Survey Co.		,,	No diary.
No. 1 Pontoon Park		,,	No diary.
No. 7 Army Tramway Co.		,,	No diary.
FIRST ARMY. I CORPS.			
12th Field Co.	6th Divn.	E.	
459th (West Riding) Fld. Co.	,,	N.E.	
509th (London) Fld. Co.	,,	,,	
465th (N. Midland) ,,	46th Divn.	,,	
466th ,, ,,	,,	E.	
468th ,, ,,	,,	D.	

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HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.	Remarks
CANADIAN CORPS.		
1st Can. Field Co.	1st Can. Div.	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
4th ,,	2nd Can. Div.	,,
5th ,,	,,	,,
6th ,,	,,	,,
7th ,,	3rd Can. Div.	,,
8th ,,	,,	,,
9th ,,	,,	,,
10th ,,	4th Can. Div.	,,
11th ,,	,,	,,
12th ,,	,,	,,

SIGNALS.

HILL 70. 15TH-25TH AUGUST, 1917.

Unit.	Formation.	Remarks.
First Army Signal Co.	1st Army	N.E.
A Corps Signal Co.	I Corps	D.
6th Divl. Signal Co.	6th Divn.	,,
46th ,,	46th ,,	,,
Canadian Corps Sig. Co.	Can. Corps	,,
1st Can. Divl. Sig. Co.	1st Can. Div.	E.
2nd ,,	2nd ,,	,,
3rd ,,	3rd ,,	,,
4th ,,	4th ,,	,,

MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.		Remarks.
SECOND ARMY.			
A Special (Cylinder) Co.	Special Bde.	E.	
K ,,	,,	,,	
L ,,	,,	,,	
O ,,	,,	,,	
P. ,,	,,	,,	
Z Special (Projector) Co.	,,	,,	
No. 2 Spec. (Mortar) Co.	,,	,,	
No. 3 ,,	,,	,,	
171st Tunnelling Co.	II Anzac Corps	,,	
175th ,,	IX Corps	D.	
177th ,,		N.E.	
183rd ,,	X Corps	E.	
250th ,,	IX Corps	,,	
1st Can. Tunnelling Co.	IX Corps	,,	
2nd ,,	X Corps	,,	
3rd ,,	II Anzac Corps	,,	
1st Aus. Tunnelling Co.		,,	
2nd ,,	X Corps	D.	Diary missing.
136th Army Troops Co.		,,	No diary.
167th ,,	IX Corps	E.	
216th ,,	II Anzac Corps	,,	
236th ,,	X Corps	D.	No diary.
285th ,,	IX Corps	,,	No diary.
290th ,,	II Anzac Corps	E.	
554th (Dundee) Army Troops Co.	,,	,,	
567th (Devon) Army Troops Co.	X Corps	,,	
568th (Devon) Army Troops Co.	,,	N.E.	
573rd (Cornwall) Army Troops Co.	,,	,,	
No. 4 Siege Co. R. Monmouth	,,	E.	
No. 351 E. & M. Co.		N.E.	No diary.

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MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.	E.	Remarks.
SECOND ARMY.			
2nd Field Survey Co.		D.	No diary.
No. 2 Pontoon Park		N.E.	
No. 5 Labour Bn. R.E.		,,	
No. 7 ,,		D.	No diary.
No. 4 Army Tramway Co.	II Anzac Corps.	N.E.	
No. 8 ,,		D.	No diary.
IX CORPS.			
67th Field Co.	11th Divn.	E.	
68th ,,	,,	,,	
86th ,,	,,	,,	
155th ,,	16th Divn.	,,	
156th ,,	,,	,,	
157th ,,	,,	,,	
81st ,,	19th Divn.	,,	
82nd ,,	,,	,,	
94th ,,	,,	,,	
121st ,,	36th Divn.	,,	
122nd ,,	,,	,,	
150th ,,	,,	,,	
X CORPS.			
101st Field Co.	23rd Divn.	E.	
102nd ,,	,,	,,	
128th ,,	,,	,,	
103rd ,,	24th, Divn.	,,	
104th ,,	,,	,,	
129th ,,	,,	,,	
228th ,,	41st Divn.	,,	
233rd ,,	,,	,,	
237th ,,	,,	,,	
517th ,,	47th Divn.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
II ANZAC CORPS.			
105th Field Co.	25th Divn.	E.	
106th ,,	,,	,,	
130th ,,	,,	,,	
9th Australian Fld. Co.,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
4th ,,	4th Aust. Div.	,,	
12th ,,	,,	,,	
13th ,,	,,	,,	
1st New Zealand Fld. Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	

SIGNALS.

MESSINES, 1917. 7TH-14TH JUNE, 1917.

Unit.	Formation.		Remarks.
Second Army Signal Co.	2nd Army	N.E.	
Corps Signal Co.	IX Corps	E.	
11th Divl. Signal Co.	11th Divn.	,,	
16th ,,	16th ,,	,,	
19th ,,	19th ,,	,,	
36th ,,	36th ,,	,,	
X Corps Signal Co.	X Corps	D.	
23rd Divl. Signal Co.	23rd Divn.	E.	
24th ,,	24th ,,	,,	
41st ,,	41st ,,	,,	
47th ,,	47th ,,	,,	
Y Corps Signal Co.	II Anzac Corps	D.	
25th Divl. Signal Co.	25th Divn.	E.	
3rd Aust. ,,	3rd Aust. Divn.	,,	
4th Aust. ,,	4th Aust. Divn.	,,	
New Zealand ,,	N.Z. Divn.	,,	

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SOME HOUSING EXPEDIENTS.

By CAPTAIN G. STREETEN, M.C., R.E.

INTRODUCTION.

The Housing Problem has been dealt with at such length in the Press that there is no need to point out the necessity for the speedy erection of a large number of houses for all classes of society and mainly for the so-called working classes. The present shortage of houses is due largely to the fact that very little building was carried out during the late war.

The demand cannot be satisfied by the sole use of normal brick construction for the following reasons:—

1. Shortage of skilled labourers, chiefly bricklayers and plasterers.
2. Difficulty in obtaining a sufficient quantity of bricks.
3. Increase in the cost of building due to the high rates for labour and the price of materials. It is impossible to build houses of normal brick construction at a price such that a reasonable economic rent can be asked. Some cheaper form of construction is desirable—if it can be found. However, it is questionable whether any of the various types of construction examined below do show an appreciable saving over brickwork.
4. The brick house takes too long to build and speedier erection is necessary if the demand is to be met.

Attempts have been made on an extensive scale to overcome these difficulties. The use of materials other than brick and plaster is being tried out. In many cases it has been found impossible to eliminate the bricklayer and plasterer altogether, but the work necessitating these trades has been considerably reduced. Bricks have been replaced to a great extent by steel, timber and concrete. Asbestos cement and various types of wall board are being used instead of plaster.

Economy in construction has been attained in various ways. Where a large number of houses of one type are required, mass production of the main components is found possible, notably in connection with steel and timber construction. The use of concrete on sites where the aggregate is easily obtainable has reduced the cost of transport of materials. Much of the internal joinery now used

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is standardised and constructed on mass production lines. For example, a glance at the advertisements in any building periodical will show a number of manufacturers of stock doors. These are mainly Continental or American, but Canada produces equally good, if not superior, doors at much the same price. Standard steel casement windows are also made by many firms. They are in most cases cheaper than wooden casements.

The cost of building is also somewhat reduced by the use of unskilled or semi-skilled labour to a greater extent than formerly. This is possible owing to the introduction of simplified forms of construction.

Cheaper materials are now being used. For instance on roofs, asbestos cement tiles have very largely replaced slates and clay tiles. The saving in cost is due to some extent to the fact that the roof timbers may be lighter with this type of covering. Cheap French and Belgian tiles are also being used largely in Housing Schemes.

The speed of erection is often increased by the use of types of construction other than brick. In some cases timber and steel sections, fabricated in workshops in large quantities, are sent to the site all ready marked for erection. They then take only a comparatively short time to put together, especially when a number of houses of the same type are to be built and the erection gang becomes practised.

By the use of a steel framework, with panels filled with brick or concrete, the roof may be put on early, thus preventing delays due to bad weather.

The preparation of carcassing for roofs, joinery etc., in workshops makes also for increased speed of erection.

There are, however, certain disadvantages inherent in some of the new types of construction which did not apply to brick houses. Where the building is made up of components fabricated by mass production in the workshop, there is apt to be lack of elasticity in design. In many cases only a small number of designs is catered for and it is impossible to vary the design without extra cost, which may entirely cancel any saving due to mass production. In other cases it may be possible to vary the design to a certain extent but the hands of the architect are tied by the fact that the size of the unit with which he has to build is very much greater than the brick. For example, in the Cuypers timber house, described below, the unit is a section measuring 4 ft. by 9 ft.

Another disadvantage, apparent particularly in timber and steel houses which have to be painted and to some extent in those concrete houses which have to be rough cast, is the increased cost of maintenance. This is often heavy compared with expenditure necessary for pointing brickwork.

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NEW TYPES OF CONSTRUCTION.

The new types of construction in use at the present time may be divided up roughly into the following categories :—

(*a*) Steel frame, (*b*) Steel, (*c*) Wood, (*d*) Concrete.

It is proposed to examine in some detail one variety of each type and to touch lightly on a few of the other varieties.

(*a*) STEEL FRAME.

DORMAN LONG.

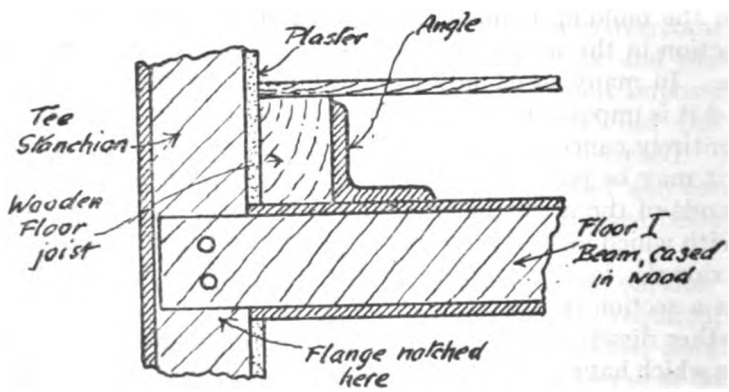
(The Dorman Housing Co., Ltd., 4, Central Buildings, Westminster, S.W.1.)

Description.—Ordinary foundations are laid. These vary of course with the nature of the soil, but the normal system is a concrete wall 18" wide and 12" deep forming the surround of a concrete raft 6" thick composed of a 2" layer of breeze concrete over 4" of ballast concrete.

A bitumen sheet damp-proof course is laid on the concrete wall. This carries a steel cill plate on which the steel frame work is erected. The cill is secured to the concrete by means of Lewis bolts at 4 ft. intervals grouted in solid with cement.

The framework consists of vertical steel tees, 4' $0\frac{7}{8}$" centre to centre, all round the building. The only places where this spacing is varied are where the chimney flues come in the outside walls. Here the stanchions are somewhat further apart. The feet of these tees are fixed to the cill plate. The stanchions are tied together at first floor level by means of an angle, and at eaves level by means of a steel flat, both of which completely surround the building.

At first floor level steel joists are carried across the building from back to front. These are attached to the tee stanchions by bolting their webs thereto after the flanges have been notched, as shown in Fig. 1.



DORMAN LONG
Fig. 1.

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These steel joists carry the timber floor joists.

The panels between the stanchions are filled with blocks made up of breeze concrete and corkboard. The corkboard is composed of granulated cork compressed in moulds and baked. Its finished thickness is 1½". It has been tested at the National Physical Laboratory, and it was found that it did not swell appreciably after being soaked in water for some hours. A slab of this corkboard 4ft. by 1ft. is placed in a mould and covered with a mixture of breeze and cement. When rammed, the finished thickness of the breeze concrete, which adheres well to the corkboard, is 2", making a total thickness of 3½" for the block.

These blocks are erected to fill the space between the stanchions, the corkboard being placed towards the outside of the building. They are laid in cement mortar and rest against the flanges of the tee stanchions.

Stout welded wire mesh reinforcement is then attached to the exterior of the steel frame by wire ties at every 18" vertically. The reinforcement is kept just clear of the corkboard slabs by means of small steel chairs which rest against the cork. Additional reinforcement is provided diagonally across the corners of all openings and down each of the angles of the building, to prevent the outer covering cracking at these points. The outer covering, consisting of rendering (1 cement, 2 sand and 2 gravel or stone chips), is applied under pressure by means of a cement gun. The finished thickness of the "gunnite" is 2". The surface may be smooth, stippled or rough cast. String courses may be provided and the gunnite may be coloured if desired.

The interior is finished with cement or plaster applied by means of the gun or by hand, to a thickness of ½".

The party wall between two semi-detached houses is composed of slabs of 1½" corkboard with 2" of breeze concrete on each side, both sides being plastered.

Partitions are of 2" breeze concrete plastered. They carry no weight.

Wall board, of which there are a number of types on the market, may be used for internal finish, instead of plaster.

Ordinary timber roofs covered with tiles or slates are provided. Timber is used in preference to steel, as it is considered that more scope is given thereby to the architect to vary his elevation.

Fireplaces and chimneys are built in brickwork. Standard steel casement windows are provided.

Cost.—This type of construction is probably no cheaper than brickwork, unless the aggregate is easily obtainable and from 30 to 50 houses are built at one time, thus allowing for repetition in steelwork.

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Remarks.—The insulation properties of the walls are very good. There is no possibility of the insulation being impaired by means of convection currents within the wall, as may be the case with ordinary hollow brick construction.

The walls are sound proof.

The roof may be erected directly the framework is completed and "wet" time saved thereby. The steelwork for a pair of parlour type houses can be erected by four men in one day. The heaviest member does not exceed 2 cwt.

It is claimed that there is no condensation on the inside walls, and this is a reasonable claim owing to the good insulating properties of the walls.

Very little skilled labour is employed. Owing to the closeness of the stanchions the breeze and corkboard blocks can be laid by unskilled labour. No plasterers are required to rough cast the outside, as is usually the case with concrete construction. The gunnite is very dense, being applied at a pressure of 60 lbs. per sq. in. Consequently the outside walls are waterproof, and there should be no danger of the corkboard becoming wet.

The position of the stanchions at 4′ $0\frac{7}{8}$″ centres rather limits the scope of the architect in design, as the windows and doors must come in the panels between the stanchions, and the length of the building is limited to some multiple of 4′ $0\frac{7}{8}$″. The width of the building can, however, be varied if the chimney flues are in the outside walls, as the distance apart of the stanchions on either side of the flues is not fixed.

Some of these houses are being erected by the Air Ministry near Wendover.

DENNIS WILD.

(Messrs. James Wild & Co. (Housing) Ltd., Engineers, 49, Deansgate, Manchester).

Description.—This is another type of steel frame building. In this case the steel stanchions are bolted to padstones formed on a reinforced concrete raft, which acts as a foundation for the ground floor walls. The stanchions are arranged within the thickness of the walls and are completely cased in concrete up to the roof.

On the ground floor, the panels between the stanchions are filled by means of an outer shell of $4\frac{1}{2}$″ brickwork and an inner shell of breeze concrete slabs, an air cavity being formed between the shells. On the first floor, the walls consist of timber framing hung externally with slates or tiles, backed with a lining of "Ruberoid" or similar material. They are lined internally with breeze concrete slabs. This system is not rigidly adhered to for the first floor walls. They may be constructed with bricks or concrete slabs externally or poured concrete may be used.

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The roof covering is of tiles supported by patent cradle roof trusses. These are composite trusses of timber and steel.

The fireplaces and chimneys are built in brickwork.

Cost.—It is stated by Messrs. Wild that this type of construction is cheaper than brickwork, but it is questionable whether this is actually the case, unless a large number of similar houses are built at one time.

Remarks.—Less than one-third of the bricks required for an all brick house are used, where the walls of the first floor are of tiles on timber framing. The bricklayer is therefore largely eliminated. As the exterior walls do not have to be rough cast and ceiling boards are used instead of plaster, the work of the plasterer is reduced to some extent.

The design of the building can be varied to a greater extent than is possible with the Dorman Long house, as the distance apart of the stanchions is not fixed, owing to the nature of the filling used in the panels between them.

The roof can be erected early, thus saving "wet" time and allowing scope for the continuous employment of all trades.

The steel framework can be used as scaffolding.

The houses can be built more quickly than brick houses. A block of 4 houses was finished ready for occupation at Blackpool in January, 1925, in 9 days after the foundations had been laid.

Messrs. Wild do not actually erect the houses, but supply the steel framework and cradle trusses and supervise the erection, which is carried out by one of their licensed contractors.

Nissen-Petren.

(Nissen-Petren Houses, Ltd., 75b, Queen Victoria Street, E.C.4).

Description.—This type of construction is quite different from the two already described, but may also be termed steel frame construction.

Concrete foundations are laid and semi-circular steel ribs are erected thereon, each being bolted to the concrete with two bolts. The ribs are each sent in five parts, which are bolted together on the site. Up to about the height of the ground floor ceilings, walling of any normal type, such as hollow brickwork, 9" brickwork rough-cast, concrete blocks, etc., is erected on the concrete foundations outside the steel ribs along the length of the building. The ends of the building are filled in with the same type of construction. The upper portion of the steel ribs forms the support for the roof covering, which consists of Robertson's Asbestos Protected Metal. It is fixed to wooden purlins, which are supported by the upper portion of the steel ribs. Roofing of asbestos cement slates is, however, being introduced as an alternative.

The fireplaces and chimneys are of brickwork.

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Cost.—It is claimed that the cost is 15% less than that for a brick house of equivalent floor area.

Remarks.—It is stated that the Nissen-Petren house can be erected in half the time required for a brick house and with half the number of skilled operatives.

Standardised joinery is used throughout.

Mass production is anticipated in the future.

The total cubic contents are reduced, owing to the adoption of the semi-circular construction. The waste of space in the roof is thereby much reduced.

The design has limitations, as the architect is restricted to a fixed width for the building, depending on the size of the ribs. In the standard designs the ribs project into the scullery and bathroom. If these designs are departed from it is necessary that the stairs should be near the lower part of the steel ribs, the space between the stairs and the outer wall on the ground floor being used only for such small rooms as scullery, larder, bathroom, etc., and it is necessary to ensure that the ribs come in the partitions between these rooms, or in such positions that they do not interfere with fittings in the rooms.

(*b*) STEEL.

ATHOLL.

(Atholl Steel Houses, Ltd., Glasgow, English representatives are: The Housing Corporation of Great Britain, 20, St. James's Square, S.W.1. The steel work is factored by J. Westwood & Co., Ltd., Millwall, E.14, and also in Scotland).

Description.—This is an all steel house, consisting of a steel framework covered with steel sheets.

The foundation is a light concrete raft deepened and reinforced under the walls.

A continuous footing angle is attached to the concrete foundation by means of rag bolts. To this are fixed angle and tee steel uprights. The angles are used at the corners of the building and the tees in intermediate positions. These uprights are connected together at first floor level by angles and channels. Along the length of the building bulb angles are used, and along the end, where there are two angle uprights at the corners and two intemediate trees, the tees are connected together by a channel, and to the corner uprights by angles. The channel supports an I beam, which runs down the centre of the building longitudinally. This I beam supports the floor joists. The uprights are also connected at eaves level all round the building by means of an angle, to which is fixed a timber wall plate carrying the roof rafters.

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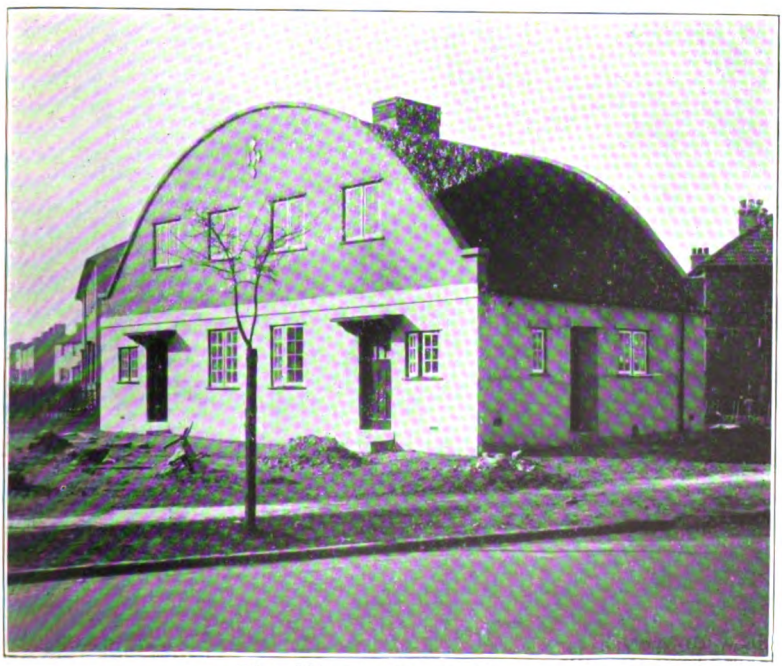
SOME HOUSING EXPEDIENTS.

The Dennis Wild House.

The Cuypers House.



The Nissen-Petren House.

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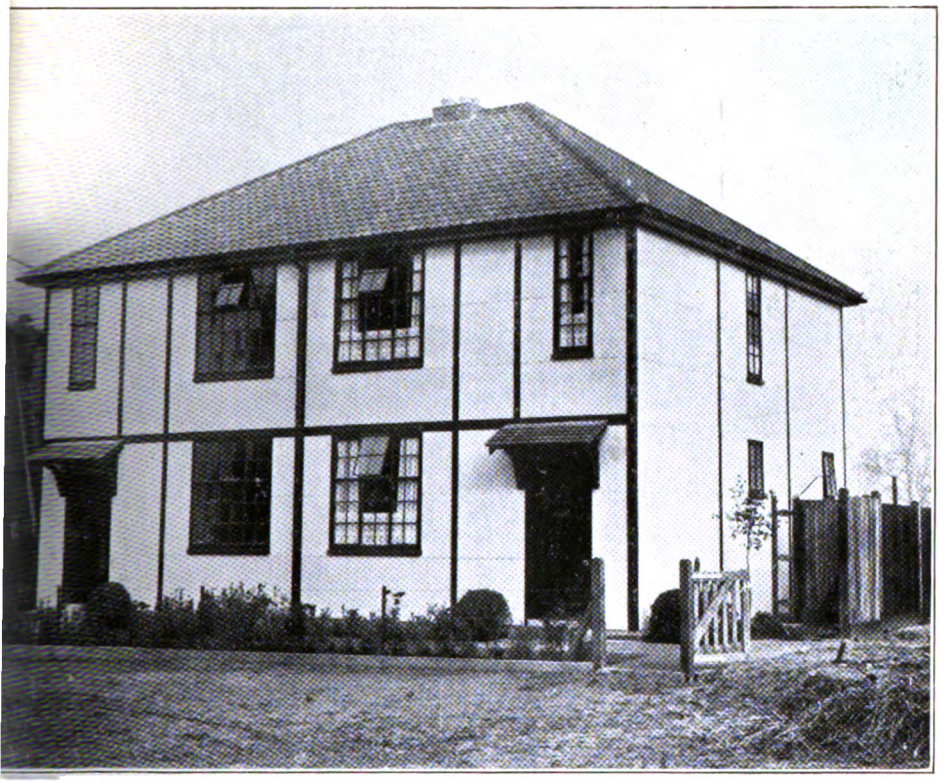

Atholl Houses at Lewisham.

Boot Concrete Houses at Birmingham.

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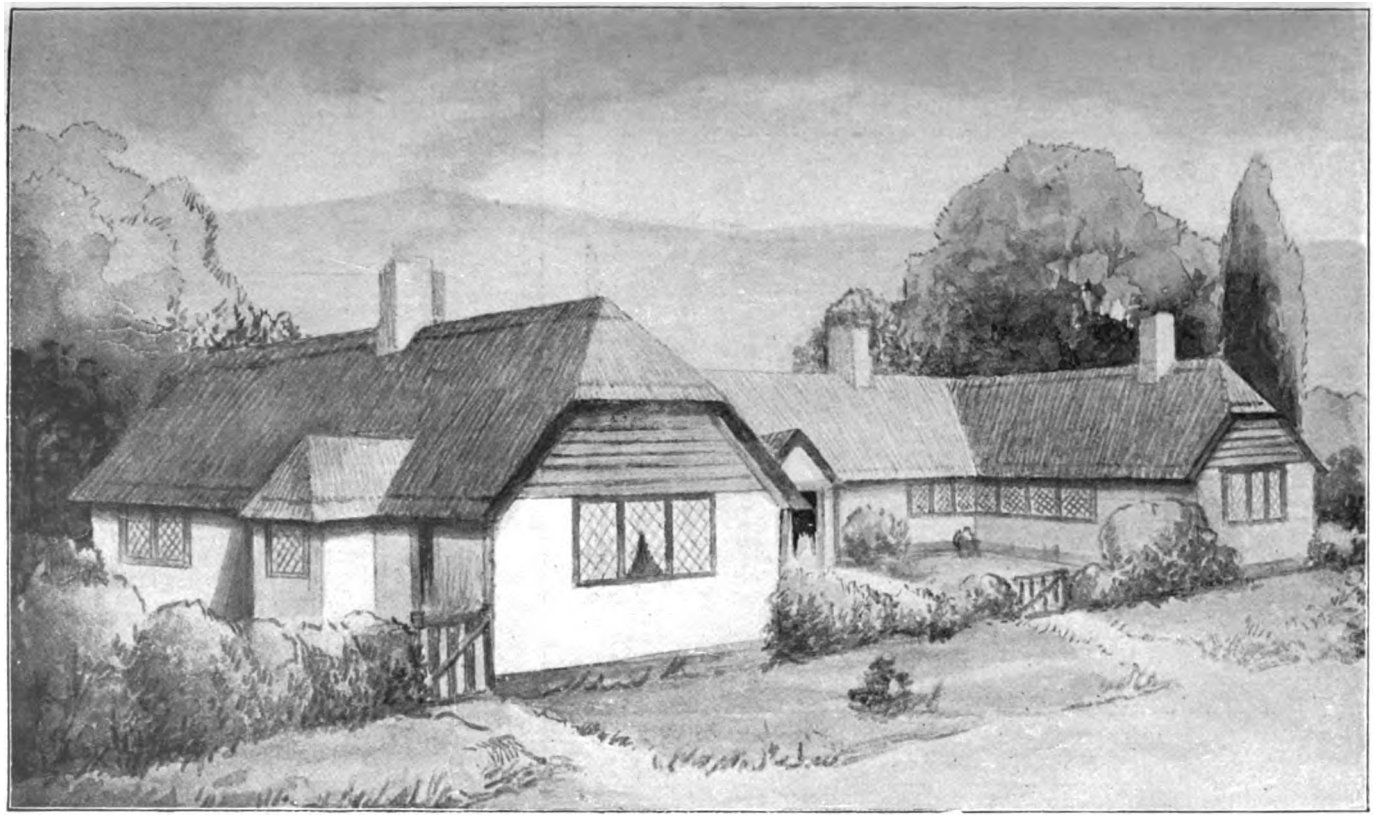

Extensible Unit Buildings (W. H. COLT, Ltd.) Bungalow.

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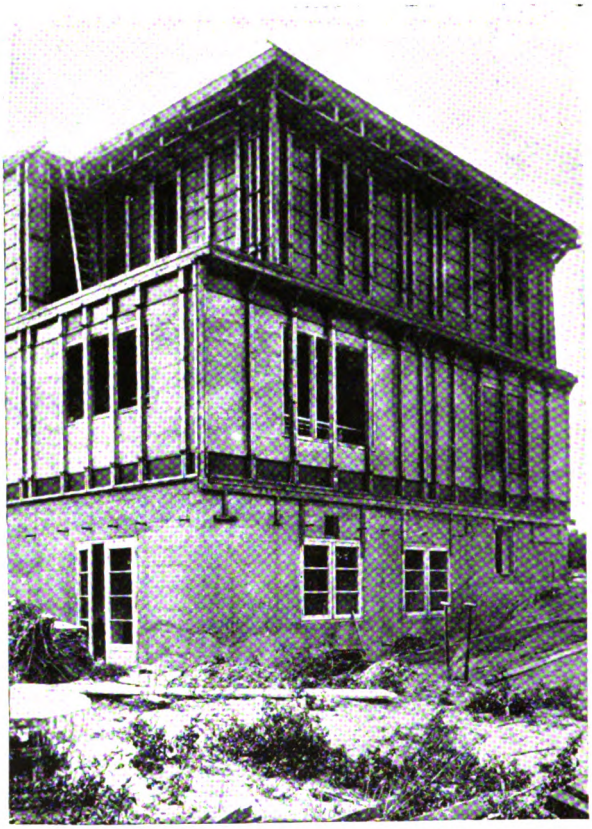
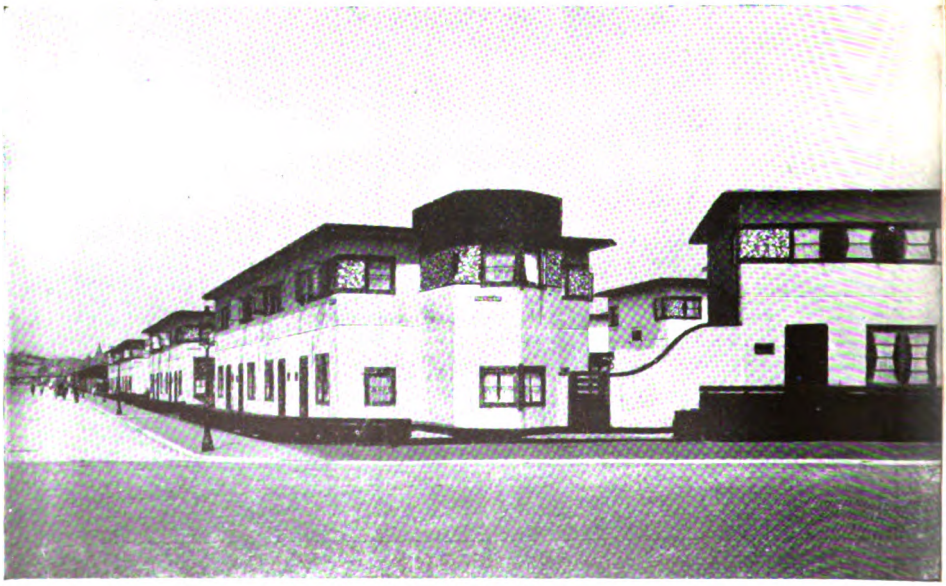


Corolite House During Erection.



Street of Corolite Houses.

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out early and gradually improved. Short cuts across the grass should be forbidden, and all transport should be *strictly* confined to the roads or to selected parking grounds. It is particularly necessary to watch this in the early stages, or the transport bringing the tents, &c., to the site may spoil the surface irretrievably.

In an ordinary camp it is usual to cook in the open, but in a standing camp cover should be provided over the cooking stoves, and also over some place for preparing and issuing food. A store is also required for meat and bread, which must be made fly-proof. The floors of these shelters should be of concrete, graded to a foul drain. As concrete floors take time to set and troops are always impatient to occupy their camps, we started a slab factory on the site of each camp, where we made up concrete slabs about 2ft. x 2ft. x 2½in. thick. These were given plenty of time to harden, and can then be laid in a few hours and are easily replaced if broken or worn. They can also be used for floors of ablution and bath rooms, and possibly for latrines.

Wherever possible we arranged a bathing establishment on the same lines as described for hired buildings, using for this purpose some neighbouring building or barn.

ACCOMMODATION FOR PRISONERS OF WAR.

If the work we did on hired buildings was that which gave us the most satisfaction, the work on prisoners' camps was the most troublesome. In March, 1915, the only prisoners' camp in the command was at Stratford (atte Bowe) in the east of London. It was an old building, such as can be met with in hundreds in London, used for general manufacture. It was large enough to provide sleeping space for 900 prisoners, but the only open ground near it was a small yard enclosed by a wire fence. The whole building was surrounded by small workmen's houses, and this was perhaps its greatest safety, as the occupants of these houses who had relatives and friends at the front, used to express their opinion of the Germans in very plain language. After the first gas attack outside Ypres the prisoners asked for permission to do without their usual exercise, as they were afraid of violence from their neighbours! Over £6,000 was spent on structural alterations to make this building habitable.

My next experience was with the Alexandra Palace. This pleasure house of iron and glass had been occupied by parties of refugees from Belgium, and, when better accommodation was found for these, was taken over for prisoners. Our first instructions, received through the General Staff of the Command, were that the Palace would hold 5,000 prisoners and would be required in a week. I at once visited the building and discussed details with the Commandant and with the D.O.R.E. The nature of the buildings made the problem

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NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-18 (*concluded*).

By BRIGADIER GENERAL W. BAKER BROWN, C.B.

CAMPS.

During the summer of 1915 there was a great demand for tent camps for the rapidly increasing number of troops who could not be accommodated in hutments. For these camps there is no regular schedule of buildings to be provided by the R.E., but in peace time each command issues its own "instructions for the formation of summer camps." These, however, are only occupied for a few weeks, while it was evident that any camps we made were likely to be occupied for the whole summer. We therefore issued in the first place only a list of buildings which should be provided, but this list was supplemented later as the need became evident. I deliberately avoided sending out type drawings, as I did not want to check the initiative of local officers, and I had full confidence in my C.R.E's. The camp accommodation provided in 1915 reached a total of 250,000 all ranks.

In the summer of 1916 we had hoped that the improved accommodation we had been able to give in hired buildings would render many tent camps unnecessary, but partly, as explained above, that a redistribution of the troops for strategical reasons was ordered by Sir J. French, and partly in order to get the troops out of the towns in the hot weather, a very large programme of camps was called for, up to a total exceeding 200,000 men, and many of these were on new sites.

A few details of our experience during these two years may be of value in future. The first and most important point was that of site, and on this point I would only confirm what I have written above in the case of hutments, that the three main points to consider are roads, drainage, and water supply.

In selecting a site, the existence of good roads is the dominant feature. In the case of a camp in a private park the camp should be put *astride* the main drive, or along the edge when the park is bounded by a road. If the road contains a main drain, and also water mains, much trouble will be saved, and it is worth going to the trouble of consulting the local authorities to secure these details.

The various establishments should be arranged along the roads and sleeping tents put just behind them. Paths should be marked

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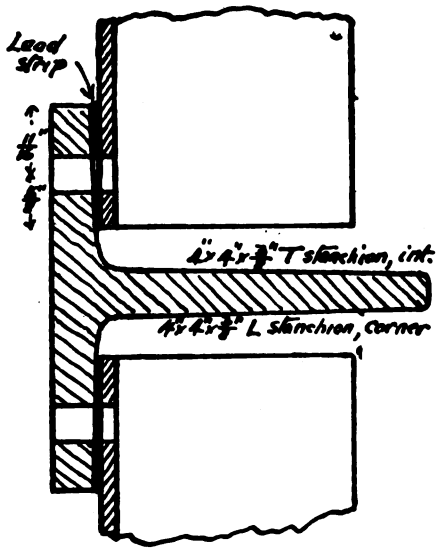
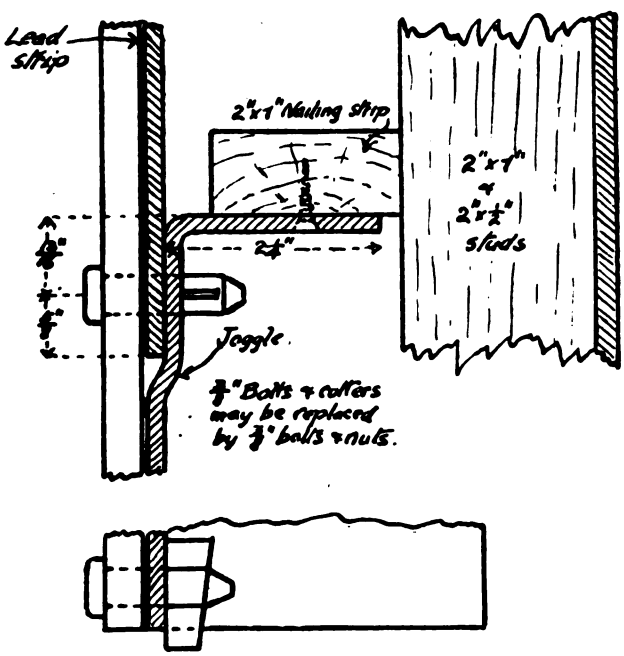


Section through stanchion, int.
Corner stanchion similar
Fig. 2.

ATHOLL.



Section of Plates at
horizontal joints.
Fig. 3.

ATHOLL

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The space between the steel uprights is filled in with an exterior panelling of steel plates, which are about 8′ 9″ long by 2′ 10″ deep, and 3/16″ thick, for a height of about 6 ft. above ground level. Above that height they are ⅛″ thick. The top edges of these plates are flanged inwards. They also have small joggles to take the lower edges of the sheets above, as shown in Fig. 3. The method of securing the steel plates to the uprights is shown in Figs. 2 and 3. A tight joint is obtained by the use of lead strips inserted between the flanges of the uprights and the steel plates.

The party wall between two semi-detached houses is constructed in a similar manner, but the steel plates are only 3/32″ thick.

The exterior surface of the steel plates is given three coats of paint. If desired, sand can be sprayed over the surface just after the second coat of paint has been given, and the third coat applied over the roughened surface. This method gives a rather more pleasing appearance than plain paint.

The interior surface of the steel plates is given two coats of paint, and while the final coat is drying granulated cork is sprayed on to the sticky surface, in order to minimise condensation on the inner surface of the steel sheets.

The inner lining of the walls consists of asbestos cement sheets on matchboarding. In place of this "Celotex" boarding has been successfully used in Scotland. If it were generally adopted, the soundproof and heat-resisting qualities of the walls would be improved. The lining is fastened to wooden studding secured in turn to battens nailed or screwed to the top of the flanges on the steel plates, in which holes for the purpose are provided. See Fig. 3.

The building is roofed with French tiles on wooden battens and rafters.

The fireplaces and chimneys are of concrete.

The partitions between rooms are of wooden framing lined on each side with matchboarding covered with asbestos cement sheets.

American ready-made joinery is used for doors, cupboards, etc., and all woodwork is treated with wood preservative and not painted.

Steel casement windows are provided.

Cost.—The house is cheaper, in first cost, than a brick house of the same floor area, but the steel requires periodical painting. It is estimated that this would cost between 30s. and 40s. a year, the capitalised value of which will bring the cost up to the neighbourhood of brickwork. It may, however, be possible to coat the exterior with some permanent protective coating such as "Caementum." In this case maintenance should be less than for brickwork, which requires pointing, but the first cost will be greater than for a painted exterior.

Remarks.—The bricklayer and plasterer are entirely eliminated. It is, however, questionable as to whether there is any appreciable

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saving in using concrete for fireplaces and chimneys rather than brickwork.

Mass production makes for cheapness, especially if the houses are erected in large numbers.

" Wet " time is avoided by the fact that the roof can be put on early.

The building will probably not be so warm and comfortable as one of brick and has not such a pleasing appearance. It is probably less soundproof and is costly to maintain.

Some of these houses are shortly to be erected at Larkhill.

WEIR.

(G. & I. Weir, Ltd., Cathcart, Glasgow).

Description.—The foundations consist of a concrete raft over the site of the building extending for a distance of 2′ 3″ all round the outside, forming a plinth. Messrs. Weir do not lay the foundations themselves except in special circumstances, but only erect the houses on foundations already laid.

The external walls consist of ⅛″ steel-plates joined up into panels 9 ft. by 9 ft., and screwed with galvanised iron screws to 4″ by 2″ wood studding. The steel plates are painted two coats on each side at the factory, and one external coat is added after erection.

There are two internal linings; first an intermediate one of felt or mill-board fastened inside the studding, midway between the steel and the inner lining, and secondly, one of "Beaver" board fixed to the studding. To guard against dry rot a few saw cuts are made in the studding to allow air to circulate in these two air spaces.

The fireplaces and chimneys are of " Ciment fondu " concrete blocks. It is claimed that as they are fire resisting there is no need to line them with fireclay.

The roof is of asbestos slates on boarding and timber rafters.

Partitions are of 4″ by 2″ wood studding with " Beaver " board on each side.

The windows are steel frame casements.

Cost.—If within easy reach of Glasgow, where the sections are factored, this type of house should be somewhat cheaper than brickwork.

Remarks.—The bricklayer and plasterer are eliminated.

Copper pipe is used for water supply throughout. The plumber is thus eliminated also.

The makers claim that the insulation value of the walls is intermediate between 4½″ brickwork plastered and 9″ brickwork plastered.

They also claim that observation has shown that there is absolutely no condensation on the inner painted surface of the steel.

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After the foundations have been laid and the materials transported to the site, a single house can be erected ready for occupation in ten to fourteen days.

Mass production lessens the cost.

Messrs. Weir send a team of 6 men to erect a small number of houses, and 2 teams of 6 men for about 50 houses.

The exterior face of the steel has to be painted periodically, thus increasing maintenance costs over those for construction in brick.

There are two standard designs. Any departure from these would probably increase the cost considerably.

TELFORD.

(Messrs. Braithwaite & Co., Engineers, Ltd., Broadway Buildings, S.W.1).

Description.—The shell of this house is made up entirely of steel plates. The plates are 3′ 6″ wide and flanged on every edge towards the inside in a similar manner to the plates which form a pressed steel tank. The plates give support to the upper floor and roof. A horizontal stringer course ties all the four walls together at first floor level. Beams carrying the floor joists run the full width of the building and are secured to this horizontal stringer.

The plates are dipped in a special anti-corrosive paint at the works and further coats are applied after erection.

Brackets are fixed to the flanges of the steel plates and a light timber studding is carried by them. To this studding thick asbestos cement sheets or other wall board are secured, leaving a 6″ air cavity in the wall. This cavity is sealed, there being no inlet from the outside air.

Party walls are also built in steel plates.

Chimneys and flues are of cast iron and chimney breasts of pressed steel.

The roof may be composed of steel flanged plates in a similar manner to the outer walls, but tiled or slated roofs are now usually provided.

Steel casement windows in wooden frames are provided.

The doors are of wood.

Cost.—The house should be considerably cheaper than brickwork, if within reasonable distance of London where the steel is factored. The cost of maintenance will, however, be greater. The walls should be painted every 3 to 5 years, and it is claimed that the cost would be £1 per house per annum. This would appear to be distinctly on the low side.

Remarks.—Bricklayers and plasterers are entirely eliminated.

The houses can be erected speedily. A pair of semi-detached houses can be completed ready for occupation within 3 weeks.

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The building is fireproof.

The units are manufactured by mass production, which makes for cheapness.

The houses are by no means soundproof, particularly if they have a steel roof. It is suggested that if "Celotex" were substituted for the asbestos cement sheets and a tile roof provided, they would be improved in this respect.

Their appearance is not very pleasing and there is difficulty in giving variety of treatment.

(*c*) Wood.

Cuypers.

(Burt, Boulton and Haywood, Ltd. (Cuypers Construction Dept.), Salisbury House, London Wall, E.C.2.).

Description.—The outer walls of the house are built up with timber framing in sections with 1" boarding vertically on one side and horizontally on the other side. There is an air cavity 2" wide in each section, the inner side of the boarding being covered with cardboard in each case. The timber used is Baltic redwood. The sections are 9' by 3' 8" and 4" thick.

The sections are grooved along their vertical edges and rebated top and bottom. They are jointed together by means of 4" by 4" vertical posts, which are grooved along three faces in the same way as the wall sections. The latter are locked to the posts by loose tongues. The posts are 9 ft. high and rebated top and bottom. Besides the ordinary sections there are special sections containing doors and windows.

The walls may be finished externally in any chosen material. They may be strapped, lathed with expanded metal lathing, and finished with cement, rough cast or hanging tiles, or weather-boarding may be used.

Normal concrete foundations are laid, a raised plinth being formed on the top. The ground floor outer wall sections and posts are set up on this plinth, the space left by the rebated edges at the bottom of the sections and posts being filled by means of a filling strip. The walls are then aligned and a horizontal binding beam is set in the rebated heads of the sections and posts, thus binding all the sections together.

The floor joists at 14" centres rest on the top edges of the sections —see Fig. 4. The space at the top of each section between the floor joists is filled with a filling strip.

A wall plate is fixed on the top of the horizontal binding beam, and the first floor sections erected thereon in the same manner as the ground floor sections.

All woodwork is planed so that the internal faces of the walls may be left plain or papered if desired. If left plain, they are painted or

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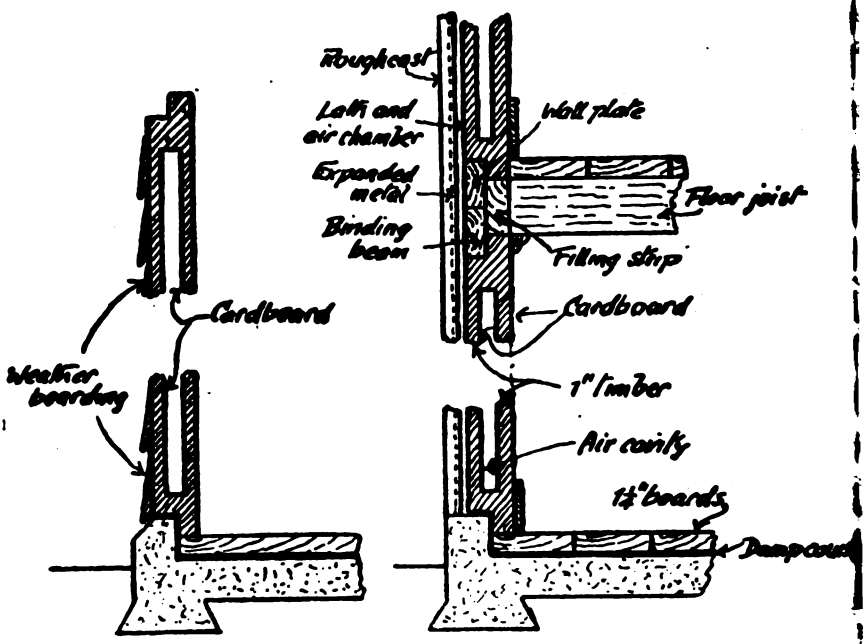

CUYPERS
Fig. 4.

varnished. If papered, a layer of carton boards or canvas is fixed to the wood.

Double casement windows are provided. It is questionable whether there is need for double windows in this climate.

The ground floor partitions are set up direct on the floor boards.

An ordinary timber roof covered with slates or tiles is provided. Chimneys and fireplaces are of brickwork.

Cost.—It is claimed that the cost is 24% less than for brickwork, but it is questionable whether this is so, even if a number of such houses are built to one design and erected by an experienced gang.

Remarks.—The walls should be good insulators judging from experience of these houses built in Scandinavia, where there is a much greater range of temperature variation than in this country.

The bricklayer and plasterer are eliminated to a great extent.

The amount of skilled labour required for erection is small. The timber is all prepared before being transported to the site, so that carpentry on the site is reduced to a minimum.

The average time taken to build a house is about 3 weeks. The houses can be occupied immediately they are built and there is no fear of damp.

It would seem that there would be considerable danger of fire with a wooden house, but this danger is not so great as might appear,

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as the houses can be insured for 1/3 per £100, which is the normal rate for houses of brick.

Planning is somewhat limited by the size of the sections and by the fact that every dimension must be a multiple of 4 ft.

3 "Group V" Married Officers quarters have been built at Bulford on this system.

CENTURY TIMBER HOUSE.

(Henry Boot and Sons (London) Ltd., 12, Lower Grosvenor Place, S.W.1.)

Description.—Messrs. Boot build two types of timber house, viz.—

1. Shingled Type.
2. Gunnite Type.

1. This is a timber framed structure covered externally on the lower storey with weather boarding laid over felt, and on the upper storey with Canadian cedar shingles. It is lined internally with wood panelling or a pulp board as an alternative to plaster.

All timber which is covered up is treated with "Solignum."

Weatherboarding or tile hanging may be used in place of the shingles if desired.

2. This is also timber framed. The framework is covered with felt, sufficiently supported to form a shuttering, against which a mixture of cement and sand is blown by means of a cement gun, reinforcement having been previously placed at the proper distance from the felt.

EXTENSIBLE UNIT BUILDINGS.

(W. H. Colt, Ltd., Bush House, Aldwych, W.C.2.).

Description.—The walls consist of timber framed sections made up of 4" by 4", 4" by 3" and 4" by 1½" scantling. The outer covering is 1" weatherboarding, which is tongued and grooved and has a chamfered edge. The sections are bolted together.

"Fiberlic," "Ten-test" or "Beaver" board is recommended as a lining for the walls, ceilings and partitions.

Special king post trusses, which drop into niches in the panel uprights, are provided, and the roof covering consists of "Ruberoid" strip slating on boarding made up in panel form.

The chimneys and fireplaces are of brickwork.

The foundations consist of concrete, brick or oak posts on which a sill is laid to carry the sections.

(*d*) CONCRETE.

BOOT.

(Henry Boot & Sons (London), Ltd., 12, Lower Grosvenor Place, S.W.1.)

Description.—This type of construction consists of reinforced concrete columns with breeze concrete panelling between.

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Normal concrete foundations are laid and footings for the columns at about 3 ft. centres are prepared. See Fig. 5. A 3" concrete seal is laid over the whole area inside the foundations.

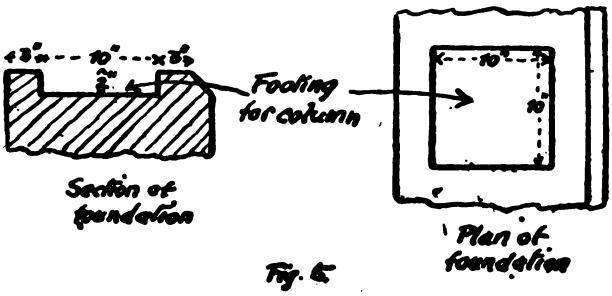
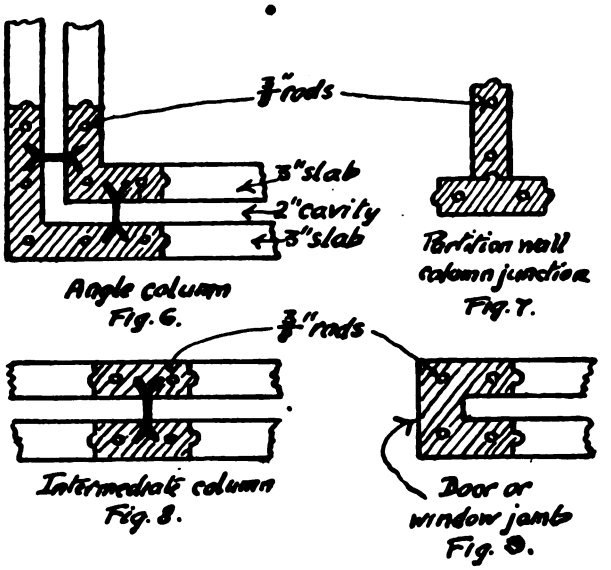


Fig. 5



BOOT

The columns are pre-cast on the site. Figs. 6, 7 and 8 show sections of angle and intermediate columns for exterior walls and those used for partition walls. It will be seen that there is a 2" air cavity in those for exterior walls. Where doors and windows occur this cavity is stopped by the use of special columns as shown in Fig. 9. On the sides of the columns tongues are cast. Grooves cast on the edges of the breeze concrete slabs fit over these tongues, which are interrupted at intervals equal to the height of 3½ slabs, and for a distance equal to the height of one slab, to allow the slabs to be placed in position. The columns are 16' 8" long and normally 8" wide, the intermediate columns being normally 8" square. Wall ties of 1" by ⅛" iron are used to tie the outer and inner sections of

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the column together. A number of special columns are also cast for particular positions, such as junctions between the party wall and the side wall. There are 17 different types of column used in each pair of houses.

The feet of the columns are set in the footings in neat cement. This acts as a damp-proof course. Below the breeze slabs a slate damp-proof course is provided.

When the foundations have been laid all the columns in the outer walls are erected. In order to keep them in position while the slabs are being laid, the next step is to place a 5" by 3" wooden wall plate along the top of the columns and bolt it to them. See Figs. 10 and 11.

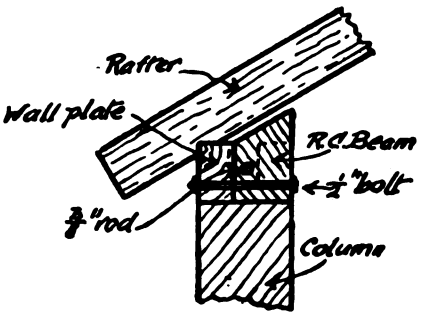

Fig. 10.

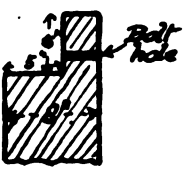

Fig. 11.

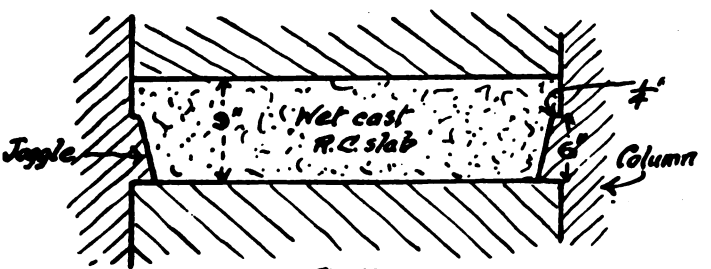

Fig. 12.

BOOT

Also at ground level the corner columns are fixed to those on each side of them by bolts, and at first floor level a series of horizontal bolts connects the columns all round the building. Five men can erect the columns for one pair of houses in one day.

The breeze concrete slabs, also pre-cast on the site, are then laid in lime mortar, the outer and inner shells being connected by iron ties.

When first floor level is reached, instead of "dry" (breeze) concrete slabs, a course of "wet" (ballast) pre-cast reinforced con-

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crete slabs is laid. These take the floor joists and transmit the weight from them to the columns, by means of joggles cast on sides of the columns, as shown in Fig. 12. Similar "wet" cast slabs are placed as lintels over doors and windows.

When the breeze concrete slabbing is finished up to the level of the wall plate, suitable shuttering is erected and a $\frac{3}{8}$" reinforcing bar is placed all round the building on top of the columns, which are then connected by a reinforced concrete beam cast in situ. The wooden wall plate forms one side of the shuttering. See Fig. 10. Five men can complete the erection of the slabs for a pair of houses in one day.

An ordinary timber roof covered with slates or tiles is used.

Partition walls on the ground floor consist of pre-cast columns 3" thick, the panels being filled in with 3" breeze concrete slabs. See Fig. 7. On the first floor the partitions are built of timber framing and lath and plaster.

The outside of the walls is rough cast and the inside plastered.

Fireplaces and chimneys are normally built in brickwork. Concrete has been used when bricklayers were not available, but it is no cheaper, owing to the complicated shuttering needed.

Cost.—It is unlikely that this type of construction would be cheaper than brickwork for houses, where less than 100 are built in one place.

Remarks.—The bricklayer is almost entirely eliminated, but the plaster work is considerably greater than for a brick house with facing bricks.

The continuous air cavity should give an equable temperature in the house.

The houses can be built quickly, and where a number are to be built in one place the parts can be made by mass production. All joinery and the necessary carcassing for roofs is made to a standard design in shops by machinery.

Unskilled labour is very largely employed.

KENT.

(Col. H. Vaughan Kent and Partners, 34, Victoria Street, S.W.1.)

Description.—This is another example of the concrete pier and panel method. It consists of pre-cast reinforced concrete piers about 4' 6" apart, the intervals being filled with concrete slabs.

A section through a pier and portion of the wall is given in Fig. 13. The outer walls are formed by inner and outer skins of concrete slabs fixed to the piers and forming an air cavity. The piers are rebated on two sides, and have projecting bolts embedded to secure the slabs of the inner skin to them. The bolts are either of non-corrosive metal or are properly protected.

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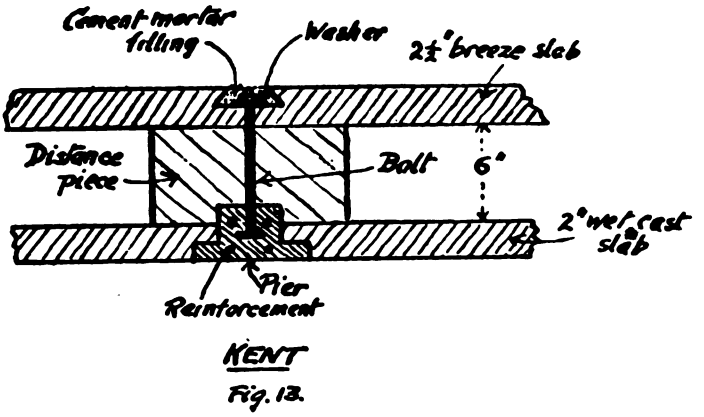

Fig. 13.

The piers are first erected all round the block, their feet being fixed into sockets in the concrete foundation and their tops tied together by a stout wall plate. They are also held in position by temporary struts.

The slabs for the outer skin are of " wet " cast concrete 2" thick and 4 ft. by 1ft. 6 in., a suitable size for handling by two men.

The concrete slabs for the inner skin are made with breeze or a similar non-conducting aggregate. They are 4' 6" by 1' 6" and 2" or 2½" thick.

After the piers have been erected the slabs for the outer skin are placed against the rebates on the piers and a joint formed by pouring cement grout into grooves on the tops of the slabs. This is squeezed out by the tongues on the undersides of the slabs above.

Small concrete distance pieces, about 12" by 6" by 6", holed for bolts, are then threaded on to the bolts, which are left projecting on the inside of the piers. The thickness of these distance pieces determines the size of the air cavity.

The slabs for the inner skin are cast with a quadrant hole and quadrant countersinking in each corner, which, at the corners, where four slabs meet, form a complete hole and countersinking, a quarter on each slab. These slabs are then placed so as to butt up against each other vertically and horizontally, the slabs being kept plumb by the fact that their corners fit close up against the distance pieces. The holes formed at the corners of four slabs correspond with the bolts which project internally from the piers. Over the end of the bolt is placed a large washer which fits into the countersinking mentioned above. The end of the bolt also lies in the countersinking and does not project as far as the inner face of the slab. After the nut has been tightened the whole of the countersinking is filled with cement mortar. See Fig. 13.

Window and door frames are secured to the piers by distance blocks in the same way as the slabs. These frames can be made of pre-cast concrete.

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Corbels or brackets are cast on the piers at first floor level to take wall plates which carry the timber floor joists.

The exterior of the wall is finished with a cement wash. Rough cast is not considered necessary.

The internal slabs fit so closely that a satisfactory finish can be obtained by the use of fabric glued to the walls.

Asbestos cement sheets or ceiling board is used for ceilings.

Cost.—This type of construction is probably no cheaper than brickwork when bricks can be obtained, unless the houses are built in large quantities.

Remarks.—Bricklayers and plasterers are eliminated. Unskilled labour under skilled charge hands can be used for casting and erecting piers and slabs.

The buildings can be erected speedily.

The air cavity should enable an equable temperature to be preserved inside, and the inner skin of breeze concrete slabs should prevent condensation.

Maintenance costs are small. No re-pointing is necessary.

Planning and architectural treatment are somewhat limited by the fixed position of the piers.

A cottage has been erected on this system at Shoeburyness as a caretaker's quarter.

COROLITE.

(Corolite Construction, Ltd., 12-13, Henrietta Street, Strand, W.C.2.).

Description.—This is a type of construction with walls formed of concrete poured in situ.

The chief point of interest in this system is the composition of the concrete. The aggregate is usually hard burnt clinker, but may be furnace slag, broken brick or pumice. It is all of a like size, small and large being screened out. No sand is used. It is mixed with cement cream so that each particle is completely covered with cement mortar. The proportions of cement to aggregate are 1 to 10 for walls and 1 to 5 or 1 to 3 for floors and roofs, a finer aggregate being used for the latter. The particles of aggregate then stick together on their salient points, leaving air cavities. These voids amount to 30% to 50% of the total volume.

The walls so formed require little finish externally or internally. It is claimed that a coating splashed on with a brush will sufficiently stop external cavities and make the wall weatherproof, while a skimming coat or almost a brush coat will finish the interior; but the exterior may be rough cast and the interior plastered if desired. Walls 9" thick are said to be waterproof with no external finish.

Special shuttering, consisting of light wooden frames covered with

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thin sheet iron plates, is used. This is made up in standardised units to suit any architectural design.

The shuttering for the first floor is more difficult to arrange and timber framed upper walls are sometimes provided.

The normal method of construction is first of all to make a 4" raft floor. The concrete for the walls is then poured to first floor level. Next the upper floor is laid, also of Corolite, and then the concrete for the first floor walls is poured.

The outer walls are 8" thick and partitions 4" thick.

Flat or pitched roofs are constructed in the same way as the floors. They are covered with a bituminous layer or tiles. Owing to the small weight of Corolite, which must on no account be tamped, it is possible to use a very light shuttering. It sets very quickly and the shuttering can therefore be removed early. No damp-proof course is required.

Cost.—If a suitable aggregate can be obtained reasonably near the site, it is claimed that the cost of this type of construction is 12½% cheaper than brickwork. This will only be the case if the houses are to be built in fairly large numbers in one place.

Remarks.—A block of 4 houses takes 2 or 3 weeks to complete.

It is stated that no condensation occurs on the walls or ceilings.

The bricklayer is eliminated and the work of the plasterer much reduced. Unskilled labour can be used to a great extent. Carpenter's work is also reduced to a minimum.

In view of the air cavities, the concrete has good insulating properties.

Aerocrete.

(The Aerated Concrete Co., Abbey House, Westminster, S.W.1.)

Description.—With this type of construction the composition of the concrete is again the chief interest.

It is made from aerated cement "Aerocrete," neat or mixed with different aggregates, such as broken stone, brick, clinker, slag, scoria, etc.

By a chemical action hydrogen is liberated, causing the mixture to swell to about twice its original volume. The mixture subsequently hardens like ordinary concrete and the resulting material has a texture resembling cork. 70% of its volume consists of small and large evenly-distributed cavities, each cavity being a closed compartment with thin walls.

It is possible to produce an aerated concrete whose weight is 20 lbs. per cu. ft. compared with the weight of ordinary concrete, about 130 lbs. per cu. ft. Aerated concrete at 45 lbs. per cu. ft. is recommended, however, as being stronger. Mixed with an aggregate the weight of course will be greater, up to 100 lbs. per cu. ft., depending upon the aggregate used.

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It is best for the exterior surface to have a brush-coat of "Aerocrete," but there is no need for internal plastering.

The concrete may be poured in situ or cast in moulds for blocks.

Cost.—This construction is cheaper than brickwork if the aggregate is easily obtainable and houses are built in large quantities, say more than 50 in one place.

Remarks.—The bricklayer and plasterer are eliminated and unskilled labour can be used to a great extent.

It is said to be three times as good an insulator as brickwork, consequently thinner walls can be used. The thickness can be reduced to the limit of weight-carrying efficiency owing to the high insulation value.

It can be worked with wood-working tools.

It is claimed that, if reinforced, it has as good adhesion to the steel as ordinary concrete.

It is said to be fireproof.

OTHER TYPES.

There are, of course, a very large number of other types of construction in use at the present time. This is particularly the case with methods of concrete construction. There are, for example, those involving (1) special shuttering for houses of concrete poured in situ (2) various types of hollow blocks (3) piers of concrete poured in situ and breeze block panels (4) a steel framework cased in hollow blocks with panels of hollow blocks (5) building moulds by which layers of breeze concrete are placed in situ (6) asbestos cement sheets and steel framework, used as shuttering for concrete and left in position, etc., etc.

It has only been possible to describe a very small proportion of the systems in use, but perhaps the examples chosen will give some idea of the number and variety of expedients which are being tried in order to produce houses quickly and cheaply, to meet the enormous demand existing at the present time.

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WATER SUPPLY ON ACTIVE SERVICE.

ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1925.

By CAPTAIN C. G. MARTIN, V.C., D.S.O., R.E.

SUBJECT SELECTED: "WATER SUPPLY ON ACTIVE SERVICE."

The essay is to take the form of a report and recommendations on the following points which arise in connection with the particular case outlined in paras. 2 to 9.

(*a*) Would it be desirable to issue any special water supply equipment to field and other engineer units of the Expeditionary Force, and if so, on what scale and how should such equipment be carried?

(*b*) What water supply stores and equipment should be sent out to the Base with the Expeditionary Force?

(*c*) What further consignments of such stores and equipment might be wanted within the next few months?

2. The Force consists of two divisions and one cavalry brigade with the normal proportion of non-divisional and L. of C. units. All are at Small War Establishment. A third division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months.

4. The climate is good on the whole but apt to be malarious in places.

5. Timber is available in most places (trees and small scantlings) in limited quantities. Building stone is generally obtainable.

6. At the Base there is a piped water supply, but if used, water would have to be chlorinated for drinking. Water is also obtainable from a river, but would require sedimentation and chlorination. The piped water supply is derived from an open aqueduct leading from springs in the hills near the town.

7. Up to 50 miles from the Base, water is said to be fairly plentiful in small streams and from shallow wells which are said never to run dry in summer.

8. Beyond that distance, water is not so plentiful and both streams and wells are apt to run dry in summer, but deep well bores would probably give satisfactory results.

9. There is no railway, but the country would admit of its fairly rapid construction. Roads are not numerous and are said to be generally unmetalled except in low-lying ground.
Country transport includes both carts and pack transport.

10. Competitors may make any reasonable assumptions supplementing the information given above, but should draw attention in footnotes to such assumptions.

The first duty of an Engineer-in-Chief on being appointed to an Expeditionary Force is to make himself thoroughly conversant with every detail of the proposed campaign. The information given in the setting of the problem is not sufficient for him to be able to make a detailed appreciation of the situation, and it has been necessary to visualise the origin of the campaign and the plan of operations from the commencement.

The full narrative will be found in Section I under the following headings:—

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1. The origin of the campaign.
2. The Plan of campaign.
   (*a*) Detail of Forces to be employed.
   (*b*) Forces of the enemy.
   (*c*) Topographical data.
   (*d*) Policy of occupation and administration of conquered country.

The information given in this section is limited to what the Engineer-in-Chief would require on which to base his appreciation of the situation for the solution of the water supply problem.

Recommendations under the headings (*a*), (*b*) and (*c*) of the setting are based on the appreciation made by the Engineer-in-Chief which is contained in Section II.

The special water supply equipment required by Field and other Engineer units are tabulated in Section III.

SECTION I.

ORIGIN OF THE CAMPAIGN IN LUCITANIA.

Under the Treaty of Lucerne the mandate for "Lucitania" was given to Great Britain in 1920.

At the capital "Lux," a High Commissioner and a small garrison had been successfully carrying on the administration, but it was known for some time that the "Stygians" have been carrying on organised propaganda among the "Lucitanians" against Great Britain, and at the end of 1923 several local disturbances broke out. These were suppressed, but in December, 1925, a general revolt broke out, the British garrison was overpowered and imprisoned, and Prince "Leo" declared himself King of the independent state of "Lucitania."

At a Cabinet Meeting held in December, 1925, the C.I.G.S. was instructed to put into operation the approved plans prepared for this eventuality, and the forces to be employed were mobilised.

PLAN OF CAMPAIGN.

The Expeditionary Force will arrive off the coast of "Lucitania" during the first week of March, 1926. Landings will be made on each side of the seaport town of "Lumen" which, when captured, will be the base of operations inland.

It is reported that the "Lucitanians," assisted by "Stygian" engineer officers, are throwing up defences on the coast line and will oppose any landing.

The objective is the capital "Lux," the centre of government and trade. "Lux" is surrounded by old fortifications built about 1870, and it is known that the "Lucitanians" have been supplementing these defences with field fortifications.

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The advance on "Lux" will be made by a force of 2 Divisions and a Cavalry Brigade, and, should the enemy be able to occupy the prepared defensive position around "Lux" without a previous battle, a third division may have to be employed.

Rapid movement and surprise are the deciding factors of this campaign, and the fullest use will be made of Mechanical Transport which, during the dry season, can move on all existing routes for wheeled traffic.

DETAIL OF FORCES TO BE EMPLOYED WITH ESTABLISHMENT.

Summary.		Men.	Horses.
1. Striking Force	2 Divisions ... ... 1 Cavalry Brigade ... Non Divisional Units	48,264	13,466
2. L. of C. Units	... ...	3,996	469
3. Base Units ...	... ...	12,521	1,774
4. Royal Air Force	... ...	2,140	
	Total ...	66,921	15,709

(1). STRIKING FORCE UNITS.	Men.	Horses.	Total. Men.	Horses.
2 Divisions	34,760	10,054		
1 Cavalry Brigade	2,119	2,329		
			36,879	12,383
NON-DIVISIONAL UNITS.				
Headquarters.				
G.H.Q. 1st Echelon	419	52		
,, 2nd ,, ...	210			
H.Qs. of Services	466	4		
Corps H.Qs.	238	35		
			1,333	91
Artillery.				
1 Medium Artillery Brigade ...	750	299		
			750	299
Engineers.				
1 Army Troops Coy.	249	20		
1 Electrical and Mechanical Coy. ...	340			
1 Light Bridging Park	92			
1 Workshop Park	187			
1 Field Survey Coy.	77			
			945	2
C.F. ...			39,907	12,793

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(1) STRIKING FORCE (*cont.*)	Men.	Horses.	Total. Men.	Total. Horses.
B.F.			39,907	12,793
Signals.				
G.H.Q. Signals	846	246		
Corps Signals	618	106		
1 Sig. Sec. Med. Art. Bde.	32	12		
1 ,, Group H.Qs., R.A.F. ...	75			
2 ,, Wing ... ,, ...	88			
6 ,, Squadron... ,, ...	126			
1 ,, Aircraft Park ,, ...	37			
			1,822	364
Tanks.				
1 Battalion	765	23		
3 Armoured Car Coys.	603			
1 Salvage Coy.	207			
			1,575	23
Medical.				
2 C.C.S.	190			
2 Motor Amb. Convoys	364			
2 Mobile H. & B. Labs.	14			
1 Adv. Depot Med. Stores	18			
			586	
Supply and Transport.				
1 Cav. Bde. M.T. Coy.	130			
2 Div. M.T. Coy.	902			
1 Med. Art. M.T. Coy.	299			
1 Tank Corps M.T. Coy.	270			
2 Reserve M.T. Coy.	732			
1 Aux. H.T. Coy.	167	231		
G.H.Q. Troops M.T. Coy.	97			
Corps Troops M.T. Coy.	428			
1 M.T. Water Tank Coy.	289			
Adv. M.T. Vehicle Recpt. Depot. ...	220			
			3,534	231
Ordnance.				
1 Ord. Mobile Workshop Light ...	30			
1 ,, ,, Med. ...	36			
1 Ammunition Coy.	112			
1 Gen. Store Coy.	112	1		
			290	1
Veterinary.				
1 Vet. Evacuating Station	43	11		
1 Adv. Depot. Vet. Stores	4			
			47	11
C.F. ...			47,761	13,423

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(1) STRIKING FORCE (*cont.*)			Total.	
	Men.	Horses.	Men.	Horses.
B.F. ...			47,761	13,423
Pay.				
1 Command Pay Unit	109			
1 Command Cash Office	6			
2 Field Cash Offices	8			
			123	
Postal.				
G.H.Q. Post Office	10			
Corps	8			
2 Convoy	10			
			28	
Provost.				
1 Provost Squadron	57	28		
1 Provost Coy.	55	15		
			112	43
Printing and Stationery.				
1 Photo Sect. A.P. & S.S.	25			
Mobile Printing Press	27			
			52	
Miscellaneous.				
Intelligence Corps	150			
Graves Registration & Eng. Unit	38			
			188	
Total ...			48,264	13,466

(2) L. OF C. UNITS.			Total.	
	Men.	Horses.	Men.	Horses.
Headquarters.				
H.Qs. L. of C.	72	6		
2 H.Qs. L. of C. Sub-area	124	8		
			196	14
Infantry.				
2 Battalions	1782	194		
			1,782	194
Engineers.				
1 Army Troops Coy.	294	20		
1 E. & M. Coy.	340			
			634	20
Signals.				
L. of C. Signal Coy.	731	32		
			731	32
C.F. ...			3,343	260

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(2) L. of C. Units (*cont.*)	Men.	Horses.	Total. Men.	Horsts.
B.F. ...			3,343	260
Supply and Transport.				
1 Aux. H.T. Coy.	117	152		
1 Adv. H.T. Depot.	66	43		
1 Res. M.T. Coy.	366			
			549	195
Remounts.				
2 Field Remount Sect.	44	14		
			44	14
Medical.				
2 San. Sect. L. of C....	56			
			56	
Veterinary.				
1 Adv. Depot. Vet. Stores	4			
			4	
Total ...			3,996	469

(3). Base Units.	Men.	Horses.	Total. Men.	Horses.
Headquarters.				
H.Q. Base Sub Area	89	4		
			89	4
Engineers.				
1 1st Class Workshop	426			
1 2nd ,, ,, ...	213			
1 Dock Coy.	153			
			792	
Supply and Transport.				
H.Qs. Main Supply Depot.	12			
1 L. of C. Supply Depot.	154			
1 Field Bakery	321			
1 Field Butchery	57			
1 Base M.T. Vehicle Rep. Depot. ...	136			
4 Aux. Motor Amb. Convoys ...	480			
1 Heavy Repair Shop M.T. ...	449			
1 Aux. H.T. Coy.	117	152		
			1,726	152
Signals.				
1 Post Depot. R.A.F. Sig. Sect. ...	66			
			66	
Remounts.				
Remount Depot H.Qs.	25	6		
1 Remount Sqdn.	303	30		
			328	36
C.F. ...			3,001	192

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(3). Base Units (*cont.*)	Men.	Horses.	Total. Men.	Horses.
B.F. ...			3,001	192
Medical.				
1 Sanitary Sect.	28			
3 General Hospitals 1200 beds ...	1008			
1 General Hospital 600 beds ...	210			
2 Convalescent Depots.	214			
1 Base Depot Med. Stores	22			
			1,482	
Ordnance.				
2 Ammunition Coys....	224	2		
2 General Store Coys.	224	2		
2 Workshop Coys.	220			
1 Boot repair coy.	108			
			776	4
Veterinary.				
1 Vet. Hospital	590	34		
1 Convalescent Home Depot ...	192	27		
1 Vet. Bact. Lab.	5			
1 Base Depot Vet. Stores	8			
			795	61
Pay.				
1 Command Pay Unit	109			
1 Base Cash Office	5			
			114	
Postal.				
1 Base Post Office	61			
1 Aux. Post Office	81			
			142	
Provost.				
5 Provost Sections	70	15		
			70	15
Printing and Stationery.				
1 Stationery Depot A.P. & S.S. ...	31			
			31	
Miscellaneous.				
1 Military Prison	31			
1 Labour Group H.Qs.	17	2		
1 Infantry Base Depot.	7			
1 General Base Depot.	7			
1 Graves Reg. & Eng. Unit ...	38			
			100	2
First Reinforcement left at Base ...			5,000	1,500
Labour Corps.			1,000	
Total ...			12,511	1,774

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(4) ROYAL AIR FORCE.	Men.	Total. Men.
1 Group H.Q.s.	47	
2 Wing H.Q.s.	94	
6 Squadrons	1,164	
1 Adv. Aircraft Park	119	
1 Aircraft Depot	688	
1 Post Depot. R.A.F.	28	
		2,140
Total ...		2,140

FORCES OF THE ENEMY.

1. The forces of "Lucitania" have been organised on the old lines existing before Great Britain took over the Mandate. It is estimated that 30,000 men have been mobilised, and that arms and munitions, supplied for the most part by the "Stygians," are available for a further 20,000.

2. It is reported that several batteries of Field Artillery have been mobilised but that ammunition for same is scarce.

3. The "Lucitanians" have obtained two squadrons of aeroplanes with Stygian airmen.

4. The armed forces of "Lucitania" are based on the capital "Lux."

TOPOGRAPHICAL DATA.

(Additional to that given in the setting).

1. Water supply at the seaport "Lumen."
   Existing supply about 300,000 gallons a day. This can be increased to 600,000 a day by improving the catchment area. Large stocks of C.I. piping are available.

2. Water supply at the capital "Lux."
   A piped supply from deep bore wells 250′ deep supplies the government organisations; it is estimated that the supply available is about 100,000 gallons a day. The inhabitants depend on rain water collected in cisterns, and on shallow wells during the rains.

3. Rainfall—average rainfall 30″.
   Rains commence on or about November 10th, and end in March; the maximum is reached in December.

4. Temperature—Maximum 105° F., Minimum 35° F.
   Readings have been taken from 1920 to 1924.

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5. Roads.
All unmetalled tracks used by wheeled traffic are suitable for pneumatic-tyred vehicles, including lorries, during the dry season.
During the rains the tracks are passable within 24 hours of rain, except in low lying areas.

POLICY OF OCCUPATION AND ADMINISTRATION OF "LUCITANIA."

On the cessation of hostilities a local administration will be set up at the capital.

It is proposed that one Cavalry Brigade will be stationed at the capital, and that the Air Ministry will take over the duty of policing the country from an air base on the coast, at Lumen, the cavalry brigade being withdrawn as soon as possible.

SECTION II.

APPRECIATION OF THE SITUATION AFFECTING THE WATER SUPPLY PROBLEM OF THE CAMPAIGN IN LUCITANIA MADE BY THE ENGINEER-IN-CHIEF, BASED ON THE INFORMATION SUPPLIED BY THE C.I.G.S.

Problem (General).

To supply a suitable and sufficient supply of water to meet every possible military situation.

Factors affecting Problem.

See Section I.

Problem (Detail).

The general problem can be sub-divided into a number of situations in which the conditions resulting from the military situation are quite distinct, and each will have to be considered separately.

These situations are—

(1). Protracted landing operations owing to strong resistance of the enemy.

(2). A rapid withdrawal of the enemy from the coast to the objective—a distance of some 100 miles—necessitating a rapid pursuit.

(3). A deliberate attack on a prepared position with a maximum concentration of forces at the decisive point.

In each of the above, the problem will have to be considered under the worst conditions from the water supply point of view, i.e., in an area where no water supply facilities are available above ground.

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The remaining problems to be considered are:—

(4). Water supply at the base.

(5). Water supply on the L. of C.

Each of these problems will now be considered in detail in the appreciation of the situation made by the Engineer-in-Chief.

LANDING OPERATIONS.

Conditions to be expected.

1. Protracted resistance by the enemy.
2. No local water supply available on landing.
3. Landing places under long range shell fire.

Requirements Necessary.

1. Supply and storage by condenser plants on ships.
2. Transport of water from ship to shore.
3. Storage on shore to allow for bad weather.
4. Distribution on shore.

Organisation of Supply.

The following water points will be required in order of urgency, sited in accordance with instructions from the General Staff, based on the plan of attack.

6 Infantry Brigade Points
1 Cavalry ,, ,,
2 Divisional Artillery ,,
2 Divisional Troops ,,
1 Point for remainder of Landing Force.

Each water point to hold three days' supply for men and animals at the rate of ½ gallon per man and 5 gallons per animal.

Gallons of water required at each point:—

	3 days' supply.
Infantry Brigade	17,310
Cavalry Brigade	37,970
Div. Artillery	47,910
Div. Troops	7,320
Other Units	41,220

Method of Storage.

Storage to be in 7,000 gallon canvas tanks.

These tanks can be rapidly erected and can be distributed over the area available, to minimise the effect of shell fire.

Number of 7,000 gallon tanks required.

6 Brigade Points	18
1 Cav. Bde. Point	6
2 Div. Art. Points	14
2 Div. Troops Points	4
Other Units	12
Total	54

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Transport from Ship to Shore.

Assuming that barges can get in close to the shore at all landing places, special tank barges will be employed to transport water from condensers to tanks ashore. Barges of a capacity of 25,000 gallons discharging 12,000 gallons an hour, through two 4" pipes against a head of 600', will be required.

These barges will fill three 7,000 gallon tanks in two hours, and allowing a round trip for filling and discharging of eight hours, each tank barge will fill nine tanks in 24 hours.

It is essential that a day's supply be put ashore within twelve hours for the attacking infantry, as no animals will be landed until the enemy have been pushed back from the shore.

This will necessitate filling one tank in each of the six infantry brigade groups and can be carried out by two tank barges, and within 24 hours one day's supply for the whole force will be on shore.

A third barge will be required as a reserve in case of a breakdown.

Distribution.

The R.E. field units will arrange distribution from the 7,000 gallon tanks, but, until it is possible to land animals, transport to the advanced troops will have to be carried out by hand.

For this purpose each infantry brigade will require 500 4-gallon petrol tins, making 3,000 in all.

RAPID PURSUIT FROM LANDING POINT TO OBJECTIVE.

General Remarks.

Two distinct operations are involved.

(1). Over the first fifty miles of well watered country.

(2). Over the second fifty miles where water is scarce.

Problem.

To avoid holding up the pursuit on account of lack of water.

Essential conditions to be fulfilled.

1. Rapid reconnaissance of available supply.
2. Rapid development of same.
3. Distribution.
4. Salvage of apparatus no longer required and transport to more advanced area.
5. Handing over installations required by the L. of C. and taking over from the water supply units of the L. of C. similar apparatus for use further forward.

Considering each of the two problems in turn.

Fifty miles of well watered country.

Conditions to be expected.

Water is reported in small streams and shallow wells which do not run dry in summer.

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Requirements necessary.

Reconnaissance, development and distribution will present no difficulty to the engineer field units, but the rapid closing down of points no longer required and opening new points in conjunction with a rapid advance will have to be considered.

The solution lies in supplying the field units with sufficient equipment to enable them to leap frog from one position to another and so have advanced supplies prepared before withdrawing the equipment in rear.

For this purpose each field company will require 12 units consisting of one lift and force pump and one 600 gallon trough; thus allowing three units to each section.

Each section will carry one 2,500 gallon trough for temporary storage of drinking water when required.

The composite field troop responsible for the water supply of the Cavalry Brigade will consist of an amalgamation of a headquarter troop and a field troop, and each of these troops will require two units as above.

Each section of a field company and the headquarter troop of the composite field troop will require an additional mechanical elevator—type Boulton and Paul.

Summary of Equipment.

Field Company.	Elevators, Boulton and Paul	8 No.
	Pumps, Lift and Force	12
	Troughs, waterproof, 2,500 gall	4
	Troughs waterproof, 600 gall.,	12
	Stores for trough, 2,300 gall.	1 set
	Stores for trough, 600 gall.	12 sets
Composite Field Troop.		
	Elevators, Boulton & Paul	2 No.
	Pumps, Lift and Force	4
	Troughs, Waterproof, 600 gall.	4
	Stores for ,, ,,	4 sets

Handing over Water Areas to L. of C. Units.

L. of C. water units will open their own water areas as required, basing same on the water reports of field units; the question of handing over equipment will not arise, as, with surface water available, L. of C. units can make use of their own equipment without loss of time.

RAPID PURSUIT (*cont.*) (SECOND AREA.)

Conditions expected.

Streams and shallow wells running dry.

Deep bore wells a possible source of supply, but none available except at the objective, where a bore of 250' deep has reached water.

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Organization.

1. *Reconnaissance.*
   Extensive reconnaissance and the rapid receipt of reports on the existing surface water are essential.
   Geological reconnaissances will in addition have to be made.
   Each section of a field company and the composite field troop will carry a Norton Tube equipment for rapid location of water below the beds of dry streams and wells.

2. *Development.*
   The development of surface water will be carried out as in the first phase of the advance; in addition, each section of the field companies and each troop of the composite troop will carry
   2 Spear Points units each consisting of
   20′ of 2½″ piping (one with steel spear point).

(This "Spear Point" will be driven by the Norton Tube equipment). One 2,300 gallon canvas tank for storage.

Consideration of the problem should no water be available during the second phase, either on the surface or within reach of the equipment of Field units.

Amount of Water required.

The strength of the Striking Force is 48,264 men.
" " " 13,466 horses
at a minimum allowance of ½ a gall. a day per man.
" " 5 gallons " horse.
Gallons of water required daily 90,000.

Requirements.

The worst conditions to be considered are a rapid advance up to the objective to be followed by an attack on a prepared position.

Assuming an area of 40 miles without water, and a rate of advance of 10 miles per day across this zone, and allowing five days before water can be obtained by bore wells, the force will have to be supplied for nine days by means of transport, for five days of which a round trip of 80 miles will have to be run.

Solution of Problem.

Water will have to be transported by motor lorry until deep bores have been sunk and the supply obtained from them.

Transport.

Gallons of water to be transported daily = 90,000.

Transport by Water Tank Coy.

87 lorries at 150 gallons = 13,000 gallons.

Transport by Reserve M.T. Coy.

16 Lorries @ 150 gallons	=	2,400
84 Lorries @ 600 gallons	=	50,400
		52,800 gallons.

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Total Transport Required.

1 Water Tank Company	13,000 gallons.
2 Reserve M.T. Coys.	105,600
	118,600 gallons.

giving a reserve of 30%.

Special Equipment necessary for Transport.

672—300 gallon iron tanks.
64—150 gallon iron tanks.

for lorries of the two Reserve M.T. Coys.

Organisation.

Initial Water Points.

Two filling points are required, each with storage capacity of one day's supply for half the force, i.e., 50,000 gallons. This will be stored in eight 7,000 gallon canvas tanks; allowing 10 hours for the lorry journey to the forward water point and 7 hours at each end, initial pump capacity when filling direct to lorries must be 8,000 gallons an hour.

Two pumps of 6,000 gallons per hour each, against a head of 250 feet, will be required at each of the two initial watering points.

Forward Watering Points.

These will consist of spill tanks of 7,000 gallon capacity. Each watering point will consist of sufficient tanks to hold a day's supply for one division and a cavalry brigade. Two such points will be required.

Tanks for each point

3 Infantry Brigades	17,310 gallons	3	7,000 gal. tanks.
1 Cav. Brigade	12,660 ,,	2	,, ,,
Div. Art. and Troops	18,410 ,,	3	,, ,,
	Total	8	,, ,,

In order to allow for leap frogging as the advance progresses, two sets of tanks will be required and an additional 100% spare to allow for damage.

Each section of the field company will carry one 7,000 gallon tank and the composite field troop four.

THIRD PHASE.

ORGANISED RESISTANCE OF THE PREPARED POSITION PROTECTING THE OBJECTIVE.

As soon as the rate of advance slows up against increasing resistance it is of utmost importance that all mechanical transport be released for the purpose of bringing up ammunition and stores for the expected deliberate attack—this can only be done by finding a new source of supply close up to the fighting troops.

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Bore holes will have to be sunk as rapidly as possible, and the troops supplied from a short distance to their rear, thus releasing the greater proportion of the water transporting lorries for other duties.

Organization of Boring Work.

Each Divisional area requires (at the minimum rate of ½ gallon per man and 5 gallons per horse) 34,000 gallons, and the cavalry brigade 13,000 gallons.

To allow the cavalry brigade to work on either flank, each divisional area must supply 50,000 gallons.

Numbers of Bores Required.

A 6" bore 350' deep with water level at 100' will supply 100 gallons a minute with a compressor lorry air lift plant, or 54,000 gallons in 9 hours. Thus each divisional area will require two bore holes and two compressor lorry plants and can supply the quantity required in 4½ hours.

To construct two bore holes 4 boring rigs are required, to allow for continuous work, and the minimum time to complete will be five days.

One electrical and mechanical company will be required for each divisional area.

Storage.

Storage will be on the same scale as the initial water point—eight 7,000 gallon tanks and transport to units at a distance from the initial waterpoint will be made by lorry transport—the same scale of spill tanks being available if required.

Water Supply on the L. of C.

The problem for the L. of C. water supply consists of supplying the L. of C. posts and the third division, which may have to march up from the base to take part in the final battle for the objective.

Existing supplies are to be found

1. at the base (to be dealt with later).
2. at about 50 miles, the initial water points for lorry transport.
3. behind the fighting troops attacking the objective at 80 miles from the base.

Addition Supplies will be Required.

Two points between 1 and 2 above and one point between 2 and 3.

Each point should be able to supply 2 Brigade groups and the L. of C. units and should have a storage capacity of 50,000 gallons.

The first two groups will consist of eight 7,000 gallon tanks and two portable petrol turbo pumps, delivering 6,000 gallons an hour against 250' head.

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The canvas tanks will be replaced by masonry tanks as soon as labour and material are available.

The third point will have to be supplied from two bore holes which will be sunk by a boring section after it has completed the work in front of the objective and it will have similar storage.

WATER SUPPLY AT BASE.

Requirements.

The base water supply will have to supply the following :—

Base units	13,000	
3rd Division	18,000	(on landing)
Civil population	10,000	
Total	41,000	

Allowing 15 gallons a day, supply must be 62,000 gallons per day.

Solution.

As there is an existing water supply in the town, this will be repaired and reorganised.

Work to be carried out.

(1). Wire off the source of supply—open up and clean the springs and generally improve the collecting area.

(2). Repair the open aqueduct and if necessary cover same to protect from contamination.

(3). Chlorinate water before it enters the pipe system.

(4). Repair existing pipe system and lay new system for the base camp.

Until the work can be completed the base supply will be obtained from the tank barges discharging into 7,000 gallon tanks.

The temporary supply required will be 65,000 gallons a day and will be stored in 10 tanks, this will allow 5 gallons a day for the base units.

Materials required for the permanent supply.

1 Wallace-Tiernan Chlorinator Type MSAM, supplying up to 1,000,000 gallons a day of chlorinated water, using up to 10 gallons of chlorine.

SECTION III.

SPECIAL WATER SUPPLY EQUIPMENT REQUIRED BY FIELD AND OTHER UNITS, AND METHOD OF TRANSPORT.

FIELD COMPANY, R.E.

Headquarters	lbs.
4 7,000 gall. canvas tanks with rope and pickets	920
500 lbs. tar	500
Chest of Implements Norton Tube	120

1 Wagon L.G.S. additional required.

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Each Section	lbs.
2 Pumps, Lift and Force with hose and spares	342
1 Elevator, Boulton and Paul with 300′ belt	400
1 Norton Tube equipment	248
2 " Spear Points " 20′ 2½″ piping	200
2 600 gall. canvas troughs with standards	164
1 2,300 gall. canvas troughs with ropes and pickets	180
2 7,000 gall. canvas troughs with ropes and pickets	460
	1,994

1 Wagon L.G.S. additional required.

Composite Field Troop, R.E.

Headquarter Troop.	lbs.
1 Pump, Lift and Force with hose and spares	171
1 Elevator, Boulton & Paul, with 300′ belt	400
1 Norton Tube Equipment	248
2 " Spear Points " 20′ of 2½″ pipe	200
1 600 gall. canvas trough with standards ..	164
2 7,000 gall. canvas trough with ropes and pickets	460
200 lbs. of tar	200
	1,843

1 Wagon L.G.S. required.

1 Troop

as for Headquarter Troop less

1 Elevator, Boulton and Paul, and

1 Norton Tube equipment.

1 Wagon L.G.S. required.

Electrical and Mechanical Coy., R.E.

4 Direct coupled Petrol-Turbo Astor Gwynne 4-stage pumps delivering 6,000 gallons at 250′ head through 4″ pipe.

4 Air compressor Lorry plants. Astor engines, Broom and Wode compressors with air pipe foot piece and discharge gear, capacity 69 cub. ft. free air at 100 lbs. pressure a min.

40 7000 gall. canvas tanks with ropes and pickets total weight 9,200 lbs.

500 lbs. tar.

10 3 ton lorries will be required.

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Landing Operations.

54 7,000 gall. canvas tanks with ropes and pickets.
3,000 4 gall. petrol tins empty with wooden handles.
3 25,000 gall. capacity tank barges with pumps and hose.

Base Water Supply.

1 Wallace-Tiernan Chlorinator Type MSAM
4 tons chlorine.

Reserve Equipment and Stores.

2400 ft. run 6" lining for bore holes.
12 Steel driving shoes.
8 Astor Gwynne Petrol Turbo Pumps.
6 Astor Engine Wade Compressor plants.
50 Pumps L. & F.
10 Spear points 20' 2½" pipe.
80 7,000 gallon canvas tanks complete with ropes and pickets.
20 2300 gallon canvas tanks complete with ropes and pickets.
100 600 gallon canvas tanks with standards.
5000 gal. Tar.

As it is anticipated that operations will be over in 6 months, and as in considering the problem equipment for a rapid advance has been provided, all equipment and stores required have been included in the initial programme and no further requirements will be necessary.

In the event of a third division being required, the question of time has been considered and the existing units have sufficient equipment and stores to prepare the water supply organisation of this division, both on the L. of C. for the march up to the front and in the concentration area for the final attack.

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BRIEF HISTORY OF THE ROYAL ENGINEERS WITH CAVALRY IN FRANCE DURING THE WAR 1914-18.

By COLONEL W. H. EVANS, D.S.O.

III. THE CAVALRY CORPS.

1. The Cavalry Corps was formed at Daours early in September, 1916, the five Cavalry Divisions being concentrated under the Fourth Army in that area in readiness for the second phase of the Somme Battle. A C.R.E. (Lt.-Col. W. H. Evans) was appointed to the staff of the newly-formed Corps, and also an Adjutant R.E. (Capt. G. E. Grimsdale). The 1st Field Squadron with the dismounted men of the 1st and 2nd Cavalry Divisions were at Carnoy employed on the construction of a cavalry track from Carnoy towards Leuze Wood and on waterpoints at Carnoy. The 2nd Field Squadron with the dismounted men of the 3rd Cavalry Division were near Fricourt employed on a cavalry track from Montauban to Longueval and Flers and on the construction of a Corps Headquarters Camp at Billon Farm. The 2nd Indian Field Squadron with the dismounted men of the 1st and 2nd Indian Cavalry Divisions were at Fricourt employed on a cavalry track from Fricourt to Delville Wood and on waterpoints at Fricourt. Prior to the attack on September 15th the Divisions were concentrated as follows:—1st at Carnoy, 2nd at Bray, 3rd at Daours, 1st Indian at Morlancourt and 2nd Indian at Fricourt, and the 1st Indian Field Squadron helped with the work being done by the 2nd Indian Field Squadron. During the infantry attacks the cavalry tracks were pushed on as far as possible, and owing to the bad weather a great deal of maintenance work was necessary. After the attack of September 25th the Corps moved to Regnere Ecluse for the winter: the 1st Cavalry Division to N.E. of Hesdin: 2nd remaining between Bray and Fricourt, with the Field Squadron working under the XIV Corps: 3rd to west of Hesdin: 1st Indian to near Crecy: 2nd Indian to Daours, the Field Squadron being left at Fricourt for work under the XIV Corps on Artillery O.P.'s and Railways.

2. On October 4th, 1916, the 3rd Field Squadron went forward to near Couin, in the Reserve Army area, for work on waterpoints near Colin Camps and on a cavalry track, which was not used: they were withdrawn on October 31st. On October 7th the 1st Field Squadron were moved to Albert: they constructed a cavalry track from Ovilliers to Courcelette and a Corps headquarters camp west of Albert: they were withdrawn on November 10th. The

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2nd Cavalry Division were withdrawn on November 5th, prior to which date their Field Squadron had constructed waterpoints for three Cavalry Divisions on the Ancre near Albert. The 2nd Indian Field Squadron were withdrawn in the middle of October. By the beginning of November the Divisions had settled into their winter areas: 1st round Samer (Squadron, Doudeauville); 2nd west of Hesdin (Squadron, Douriez); 3rd south of Montrieul (Squadron, Les Puits Berrault); 1st Indian south of St. Valery-sur-Somme (Squadron, Boismont); 2nd Indian north-east of Tréport (Squadron, Embreville). Owing to transportation difficulties it was proposed to send as many Divisions as possible to the Department of the Orne, but this project was abandoned. The winter was spent in providing a certain amount of hutting and stabling, horsedips, etc.; a good deal of training was done and officers were sent to Bridging Courses at Aire and Field Company Commanders' Courses near Hesdin. It was decided to withdraw boat wagons from Field Squadrons, and on February 5th the Cavalry Corps Bridging Park was formed near Boismont, consisting of three Bridging and one Park Sections. The two Indian Divisions and their Field Squadrons were re-named the 4th and 5th early in 1917, and the Canadian Field Troop was finally absorbed into the 5th Field Squadron. During the winter each Division supplied Pioneer Battalions, usually with a few R.E., for work with Infantry Corps and on new railway lines.

3. On February 10th, 1917, a preliminary reconnaissance was carried out for cavalry tracks east of Arras. And on March 11th detachments from the 1st, 2nd and 3rd Field Squadrons with dismounted men from their Divisions (under Capt. Davidson, Majors Richards and Shannon) commenced work on these tracks; Lieut. E. Rait Kerr was dangerously wounded while working on the 3rd Cavalry Division track and was awarded a bar to his Military Cross for gallantry. At the same time other detachments from these Divisions constructed waterpoints near Aubigny, Bailleulmont and Gouy respectively. An advanced Corps Headquarters was also constructed at Duisans. The 25th Infantry Division (changed later to 17th) were attached to the Corps for operations and waterpoints put up by them near Berlencourt. On March 19th, 1917, the 4th and 5th Cavalry Divisions moved up to join the Fifth and Fourth Armies respectively, a Brigade of the 4th Cavalry Division having already moved forward a few days previously: the 4th Field Squadron were employed on waterpoints near Sapignies and a cavalry track near Bullecourt: the 5th Field Squadron accompanied their Division in the advance of the Fourth Army and were employed on filling craters, road work and constructing reserve defence lines, being located at Tertry. On April 6th, 1917, Corps Headquarters moved up to Duisans and for the attack on

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April 9th the 2nd and 3rd Cavalry Divisions moved east of Arras, operating under the Third Army; the 1st Cavalry Division operating under the First Army north of the Scarpe. The Park Section of the Bridging Park were employed to carry up wire and pickets after the 2nd and 3rd Divisions. On April 11th the cavalry were withdrawn and by April 20th Corps Headquarters were back at Regniere Ecluse, the Divisions being disposed thus:—1st east of Hesdin (Squadron at Wail); 2nd round Henu, north east of Doulens; 3rd east of Crecy (Squadron at Wadicourt); 4th round Marieux, east of Doulens; the 5th along the Omignon Valley. A detachment of the 1st Field Squadron was employed on constructing at Corps Reinforcement Camp near Frevent.

4. On May 9th the Corps, with the 2nd, 3rd and 4th Divisions, moved down to the Peronne area, between the Omignon and Cologne Rivers, joining up with the 5th Cavalry Division. A portion of the front line between the Omignon River and Epéhy was taken over from the 59th and 42nd Divisions and all four Cavalry Divisions put in, the order of battle being 5th, 4th, 2nd and 3rd: Corps Headquarters took over from the III Corps at Catelet and the Divisions were disposed along the Omignon and Cologne Rivers. The C.R.E. was allowed three temporary Field Engineers to assist him in the work of the Corps area (Lieuts. A. J. Hingston, A. E. Hughes and G. Buswell); Nos. 281, 282 and 565 A.T. Companies R.E., No. 180 Tunnelling Coy. R.E., No. 3 Reinforcement Coy. R.E. and No. 4 Pontoon Park were attached to the Corps. Apart from the ordinary R.E. work connected with the administration of a large area in a devastated zone, a great deal of work was done on improving defences, and the Corps were complimented by the C. in C. and the III Corps Commander, on the state in which they left the defences. Major V. A. Simon, 3rd Field Squadron, and Capt. D. Wise, 2nd Field Squadron, were killed on June 3rd and May 15th, respectively, east of Ronssoy. The dismounted men of the Divisions were formed into the British and Indian Entrenching Battalions (Major Ricardo and Lt.-Col. R. M. Bell) and employed on constructing a reserve defence line known as the "Brown Line." During this period the 1st Cavalry Division were employed with the First Army near Merville; they were employed on reserve positions and communication trenches on the Vimy Ridge.

5. On July 3rd, 1917, the 3rd Cavalry Division moved up to the First Army area and on July 5th the Corps handed over their trenches to the III Corps (34th and 35th Divisions). Corps Headquarters moved to Aire and the Divisions were located thus:—1st, Merville, 2nd, round Magnicourt along the Canche; 3rd, Busnes, near Lillers; 4th, remaining with the Third Army along the Omignon; 5th, north of St. Pol (Squadron at Troisvaux). On July 22nd a Brigade of the 1st Cavalry Division and the 1st Field Squadron

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joined the 2nd Army, moving between Watten and Dickebusch; the Field Squadron were mostly employed at the latter place on waterpoints, corduroy roads, etc. On July 26th the 3rd Field Squadron moved to Westoutre to prepare for operations in the Second Army area; they were employed on waterpoints, Corps Reinforcement and Remount camp near Bailleul and advanced Corps headquarters at Dickebusch and later at Poperinghe. On October 4th the 1st and 5th Cavalry Divisions started off by the Elverdinghe and Watou areas, but were at once recalled. On September 1st a Cavalry Corps Horse Show was held, the prize for the best Field Troop going to the 4th Field Squadron (Lieut. S. G. Bennett, Troop Leader).

6. At the end of August, 1917, it was decided to construct huts and stables for the Corps in the area between the Cologne and Omignon rivers and work was commenced on September 16th, the whole of the 4th (at Athies) and detachments from the 2nd, 3rd and 5th Field Squadrons being employed, together with dismounted men from these Divisions: in the middle of October the whole of the 2nd and 3rd Field Squadrons were moved down for hutting work to Brusle and Flamicourt. At the end of October preparations for the Cambrai operations were commenced; a detachment of the 3rd Field Squadron constructed waterpoints for three Divisions at Fins, also an Advanced Corps headquarters there; a track-making Battalion was formed from the dismounted men of the 4th and 5th Cavalry Divisions and trained under Lieut.-Col. R. M. Bell and Lieut. S. G. Bennett, 4th Field Squadron: a bridge for crossing the St. Quentin Canal was prepared by Lieut. H. D. Maconochie, 3rd Field Squadron, and arranged for loading on to two tanks. On November 20th the operations commenced, Corps Headquarters moving from Billers Carbonnel to Fins; the 1st Cavalry Division were employed towards Bourlon Wood; the 5th Cavalry Division, followed by the 2nd Cavalry Division, used the track constructed during the attack by the Indian Entrenching Battalion from Gouzeaucourt via La Vacquerie to Masnierres with the aid of twelve wirepulling tanks; the 4th Cavalry Division were in close reserve at Fins, a brigade with the Field Troop being detailed for work under the III Corps; the 3rd Cavalry Division was in reserve in the Bray area. The specially prepared bridge was used to improve an existing bridge east of Masnierres and facilitated the withdrawal of the Canadian Cavalry Brigade: Lieut. Maconochie was awarded the Military Cross. By November 27th the Corps had moved back to Villers Carbonnel and commenced taking over a portion of the trench line between the Omignon River and Hargicourt, the 2nd Cavalry Division having been left up at Fins.

7. On November 30th, 1917, the Germans counter-attacked in

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force south of Cambrai. Corps Headquarters moved to Villers Faucon and the 2nd and 5th Cavalry Divisions came into action between Epéhy and Gouzeaucourt, the 4th Cavalry Division being in support at Villers Faucon and the 1st and 3rd Cavalry Divisions in support of the VII Corps along the Cologne River: later the 1st and 4th Cavalry Divisions took over from the 2nd and 5th. The Field Squadrons were employed on the construction of support lines and strong points. On December 6th the Corps moved back to their winter area, Corps Headquarters moving to Villers Carbonnel: the trench line between the Omignon Valley and Ronssoy was taken over from the VII Corps, the 24th Division being included in the Cavalry Corps. The left sector of the line was taken over by the 24th Division and the right sector by an organisation called the Dismounted Divisions, consisting of two of the Cavalry Divisions in turn; Major A. F. S. Hill, of the 4th Field Squadron, was appointed temporary C.R.E. of the Dismounted Divisions. The C.R.E. was given three extra officers to assist him, Capt. R. G. Wright, Capt. E. O. Pearce, who had joined in September as Hutting Officer, and Lieut. G. Buswell: Nos. 239, 281 and 288 Army Troops Companies R.E. and 258 Tunnelling Company R.E. were attached to the Corps. A great deal of hutting work was carried out, as well as work on defences, including a number of switch lines, dug-outs, etc.; workshops were formed at Brie and all the bridges in the area were prepared for demolition. At the end of February, 1918, the 4th and 5th Cavalry Divisions were withdrawn to the Longpré area, preparatory to being sent to Egypt: the 4th Field Squadron was sent to Ailly-le-Haut-Clocher, where it was broken up: the 5th Field Squadron were retained for work on Corps defences. On March 9th the Corps handed over to the XIX Corps, the 24th Division, after relief by the 66th Division, taking the place of the Dismounted Cavalry Divisions in the line. Corps Headquarters moved from Catelet to Villers Carbonnel, the three Divisions remaining along the Cologne and Omignon Rivers. The Corps were put in charge of the Army Line (the Green Line), Brig.-General Armstrong, Canadian Engineers, being put in charge of the work, the C.R.E. being given a sector to look after with the Field Companies and Pioneers of the 50th Division, the 225th Field Company, Nos. 283 and 288 A.T. Coys. R.E., in addition to the Field Squadrons and a number of Labour Units.

8. Prior to the German attack on March 21st, 1918, the 2nd Cavalry Division had gone down to the Oise to join the III Corps. On the 21st the 3rd Cavalry Division was also sent down to the III Corps area, the 1st Cavalry Division and the 5th Field Squadron put under the XIX Corps, and Cavalry Corps Headquarters moved back to Moreuil. The 1st Cavalry Division were in action several times during the retreat: on the 23rd the Field Squadron blew

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up the bridge over the Somme at Pargny and Bethencourt, 2nd Lieut. Baylay being killed: on the 24th they were at Cappy and Cerisy under the VII Corps, and on the 25th at Bussy-le-Daours holding the line north of the Somme about Morlancourt: on this day they again came under the Cavalry Corps, which had arrived at Querrieu. The 2nd Cavalry Division were at Maucourt on the 21st, and the Field Squadron reconnoitred the bridges over the Oise for demolition: on the 23rd Lieut. Kezar's Troop were in action at Jussy with the 3rd Cavalry Brigade, the other troops being detached to the 4th and 5th Brigades and rejoining the Squadron on the 27th. Meanwhile Squadron Headquarters on the 22nd and 23rd prepared 14 bridges about Marucomp and Quierzy for demolition and again two more at Appilly and Bretigny on the 24th, which they blew up on the 25th, the bridge at Pontoise being demolished the same day. On the 29th the Squadron dug posts at Dive Le Franc, handing over to the French, and again the same thing at Ansauvillers, whence they marched north to Boves, on the 30th rejoining the Cavalry Corps. The 3rd Cavalry Division joined up with the 2nd Cavalry Division under the III Corps: on the 26th the Field Squadron assisted the French to blow up some bridges near Pontoise: on the 27th the Division assembled near St. Just, and on the 30th rejoined the Corps at Sains-en-Amienois. The 5th Field Squadron, after retreating daily, were on March 25th joined by two Tunnelling Companies and four A.T. Companies of the XIX Corps, forming the XIX Corps R.E. Battalion, of which Major Buchanan was placed in command, and Capt. Fairclough appointed Adjutant: on the 25th the Battalion blew up a culvert between Estrées and Foucacourt, and on the 26th they dug and manned the Framerville-Varvillers line: on the 27th they retired to the Rouvroy to Framerville line, where they were heavily attacked and had to retire to the Le Quesnil-Beaufort line, Lieut. Matthewson being killed at Rouvroy. The Battalion was reorganised at Cayeux, and again put into the line at Demuin, where they were heavily attacked and had to retire to Hangard, consolidating a position there and being withdrawn on the 31st to near Boves: Major Buchanan was seriously and Lieut. Greathead slightly wounded during the action at Demuin. The Squadron joined the Corps near Glissy on April 1st and were employed on constructing a trestle and a pontoon bridge over the Somme. The 1st Cavalry Division, on April 27th, were hastily transferred from the north to the south bank of the Somme to fill a gap in the line: they occupied this line till May 3rd, the Field Squadron being employed in support and also on preparing some of the bridges about Daours for demolition. On April 1st the 2nd Cavalry Division, with part of the 3rd Cavalry Division, attacked at Hangard Wood, north-east of Moreuil:

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the 2nd Field Squadron followed up to consolidate, when Major Swinburne was killed and Lieut. De Meric wounded. On April 3rd the 3rd Cavalry Division went up in support north-west of Gentelles, and the Field Squadron was employed on the Cachy Switch until the 8th. On April 6th Corps Headquarters withdrew to Amiens with the 1st and 3rd Divisions, the 2nd Division moving back to Ailly-le-Haut-Clocher. The 5th Field Squadron were sent to the Base and broken up.

9. On April 10th, 1918, Corps Headquarters moved to Auxi-le-Chateau, and on the 17th to St. Quentin, near Aire, in consequence of the German attack about Merville, the Divisions being located—1st, at Heuchin (Squadron Livossart); 2nd, Blaringhem, 3rd, Pernes (Squadron Sains-les-Pernes). On April 27th the 2nd Cavalry Division moved back to Mont Cavrel, near Montreuil (Squadron at Alette), Corps Headquarters moving on May 5th to Auxi, the 1st Cavalry Division to Bomy, (Squadron Rupigny) and 3rd to Contay in the Fourth Army Area, where the Field Squadron (at Behencourt) with dismounted Cavalry were employed on III Corps rear defences. On the 16th May the 3rd Division withdrew to the Yvrench area (Squadron at Bettencourt-St.-Ouen), leaving a Brigade and a Field Troop working on trenches until July. A good deal of R.E. work was done during the summer for the Cavalry School at Dieppe, where Capt. S. G. Bennett was appointed R.E. Instructor, the Equitation School at Cayeux, where officers from each Field Squadron were sent to attend the courses, the Corps Reinforcement Camp at Abbeville, and the Corps Convalescent Camp near Cayeux. All Squadrons were trained in bridging, and the 1st and 2nd Squadrons drilled with the Inglis Bridge. On May 21st the 2nd Field Squadron went up to Houdain, until July, to work on a reserve line under the X Corps, employing Chinese labour. On May 22nd the 1st Division moved to the Auxi area (Squadron at Gueschart, and later at Villeroy sur Authie). During June the C.R.E. and some officers from Field Squadrons worked on Defences east of Doulens for the C.E., Third Army. On July 3rd the 3rd Field Squadron moved to Dreuil, until July 30th, for work on rear defences, with Chinese labour, under the C.E. Fourth Army. On July 11th the 2nd Field Squadron moved to Willencourt for training in bridging. On July 14th the 1st Cavalry Division moved forward in support of the Third Army to Beauval (Squadron, Gezaincourt), moving back on the 30th (Squadron, Beauvoir Riviére). On July 15th the 2nd Cavalry Division moved up in support of the First Army to Le Couroy (Squadron at Sars-le-Bois), moving back on the 22nd (Squadron, Willencourt).

10. On August 6th, 1918, Corps Headquarters moved to Yzeux, taking the Water Point Section of the Bridging Park, and the Divisions concentrated west of Amiens for the Fourth Army attack

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on August 8th. Owing to the secrecy preserved regarding the operations little preliminary R.E. work was possible: the 3rd and 1st Field Squadrons prepared tracks through the trenches for their Divisions and the A.D. Roads, Fourth Army, sanded the pavé roads through Amiens for the night of August 7th to 8th, when the Divisions marched through and concentrated by dawn east of the town, Corps Headquarters moving to Longueau. From the cavalry point of view the attack was a great success, but owing to the rapidity of the advance, very little R.E. work was possible: the 3rd Field Squadron reconnoitred the crossings over the Luce. Corps Headquarters moved forward to Cayeaux-en-Santre on the 8th and to Caix on the 10th, the Bridging Park being ordered up to Cayeux: on the 11th the 2nd Field Squadron employed the waterpoint section at Vrely. On August 12th Corps Headquarters moved back to St. Fuscien, the Divisions withdrawing to along the Somme and Avre east of Amiens. On the 16th Corps Headquarters moved back to Auxi, 1st Division east of Auxi, 2nd between Auxi and Canaples, 3rd Yzeux. On August 20th the 1st and 2nd Cavalry Divisions moved east of Doulens and on August 25th their Field Squadrons were employed on water supply work at Ablainzeville and Miraumont, respectively, Corps Headquarters moving to Hauteclocq (south of St. Pol): the 34th Mobile Infantry Brigade in busses was attached to the Corps for operations on the Third Army front, but the Corps were not used and returned to Auxi early in September, the 1st Division being located east of Auxi (Squadron at Wavans). Meanwhile the 3rd Division moved up west of Auxi (Squadron at Haravesnes), and the 2nd Cavalry Division were split up, 3rd Brigade with a Field Troop to First Army, 4th Brigade to Third Army, 5th Brigade, with a Field Troop, to Fourth Army, Headquarters and remainder of Field Squadron at Gaudiempre and Grenas, north east of Doulens. On September 15th the Corps were set a tactical scheme in the Auxi area in conjunction with Infantry in busses.

11. On September 27th, 1918, the Corps (less 2nd Division) moved down into the Fourth Army area, Corps Headquarters going into camp about Aizecourt-le-Haut (north of Peronne), 1st Division along the Cologne and 3rd along the Omignon Rivers. The 4th Guards Brigade, with a battery of R.F.A., and the Household Machine Gun Brigade, all in busses, were attached to the Corps, as well as the 18th Corps Cyclists: a made-up bridge in three spans, with Weldon trestles, to carry busses, was carried on five lorries, together with a party of sappers under Lieut. Matthews, from 648th Field Company R.E. On several occasions the Corps moved forward to follow up the Infantry attack, but it was not until October 8th that the situation permitted of the employment of Cavalry: on that day the Corps moved forward

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across the St. Quentin Canal, Corps Headquarters moving to Estrées: the 1st Cavalry Division were in action about Seraing and Premont, and a troop of their Field Squadron was used to support an attack about Premont: the next day the 3rd Cavalry Division were engaged towards Le Cateau and Corps Headquarters moved forward to Seraing, advancing to Bertry on the 11th. During this battle a great deal of R.E. work was done by the Field Squadrons: the waterpoint wagons of the Bridging Park (3 deep well sets) were used at various villages with excellent results, watering large numbers of horses belonging to all formations: a number of mines and German traps were removed or rendered safe: a good deal of work was done in filling craters, making diversions round craters, etc., the 18th Corps Cyclists assisting in the work. On the 14th, Corps Headquarters moved back to Aizecourt-le-Haut, the 1st Cavalry Division going to Tertry and the 3rd to Manancourt. Meanwhile the Field Troop attached to the 5th Cavalry Brigade had been doing good work during the battle in the neighbourhood of Bohain, while Lieut. Lloyd was lucky enough to be in time to cut the wires laid for firing a large German ammunition dump: this Brigade was withdrawn to Catelet about October 15th, and employed on the construction of a Reinforcement and Remount Camp at Clery.

12. On November 7th, 1918, the Corps (less the 2nd Cavalry Division) moved up to the Lille area, Corps Headquarters going to Seclin and the Divisions west of the Escaut Canal, south of Tournai (Squadrons at Poissonniére and Attiches): preparations were made for operations with the Second Army, two made-up bridges on pontoon waggons, for crossing canal locks, being attached to the 1st Field Squadron, and a Bridging Section from the Bridging Park to each Field Squadron. On November 10th Corps Headquarters moved to Genech and the Divisions crossed the Escaut Canal, going forward into the battle on the 11th, but being stopped at 11 a.m., on account of the Armistice, along the Blaton Canal about and south of Ath. On November 13th Corps Headquarters moved to Tournai, the two Divisions being located east of the Escaut Canal (Squadrons at Wier and Vezon). Meanwhile the 2nd Cavalry Division collected about Cambrai, moving forward to Le Quesnoy prior to leading the advance of the Fourth Army to the frontier, the Cavalry Corps being allotted to the Second Army for the same purpose. The march forward commenced on November 17th the 1st Cavalry Division being on the right, and the 3rd on the left of the Second Army front. Corps Headquarters moved forward via Silly, Braine-le-Comte, Genappe, reaching Namur on the 22nd: here it was decided that the 1st Cavalry Division only should go forward, the 3rd remaining where they were for the present (Squadron, Perweiz). On September 27th

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the move forward continued, Corps Headquarters moving via Huy, Ouffet and reaching Stavelot on the 29th, the 2nd Cavalry Division, in front of the Fourth Army, having reached Marche (Squadron, Marloie). On December 3rd a section of the Bridging Park was broken up in order to provide reinforcements for the 1st Field Squadron, who had suffered severe losses on account of influenza. On December 1st the 1st Cavalry Division continued the march into Germany under the Second Army, Corps Headquarters with the 2nd and 3rd Divisions remaining with the Fourth Army. On December 12th the 1st Cavalry Division crossed the Hohenzollern Bridge over the Rhine at Cologne, returning shortly afterwards to their winter area just west of Cologne (Squadron at Modrath). On December 11th Corps Headquarters moved to Spa, and on the 17th the 2nd and 3rd Cavalry Divisions settled into their winter areas south of the Meuse on either side of the Ourthe (2nd Field Squadron at Tilff, 3rd at Schlessin, Bridging Park at Embourg, all near Liège). Towards the end of December Nos. 146, 221, and 574 Army Troops Companies R.E. joined the Corps, the two former being allotted to the 3rd Cavalry Division and the latter to the 2nd. During the advance through Belgium the only R.E. work done was road reconnaissance and removal of German mines. During the winter, apart from the ordinary minor R.E. services, the following works were carried out:—demobilisation camp at Seraing; G.H.Q. Training School near Engis; establishment of various workshops for educational purposes.

13. In conclusion, mention should be made of Captains W. Walker, M.C., R. F. Young, M.C., and R. F. Fagan, who for a long time were Medical Officers to the 2nd, 3rd and 5th Field Squadrons, respectively; also of the following Interpreters:—Bing, who was with the 3rd Field Squadron throughout the war; H. Mayerwaerth, P. Thieux and E. Oliver, with the 4th Field Squadron; and P. Canivet with the 5th. Major J. A. Church, 13th Hussars (R. of O.), was for many months attached to the 4th Field Squadron, and Lieuts. C. T. St. Quintin and N. T. Secombe to the Cavalry Corps Bridging Park.

ERRATA.

On p. 45 *line* 24 *for* Aldershot *read* LUDGERSHALL.
On ,, ,, 28 *for* Westoure *read* WESTOUTRE.
,, ,, ,, 35 *for* Reninghels *read* RENINGHELST.
,, ,, ,, ,, *for* St. Vans Cappel *read* ST. JANS CAPPEL.
,, p. 48 *lines* 15 *to* 19 *Delete from* On December 31st to February 15th, 1916, *and substitute*:—
On December 31st, 1915, the Corps formed a Dismounted Division for duty in the trenches. This Composite Division proceeded to PHILOSOPHE and took over that part of the front line, which included the HOHENZOLLERN Redoubt, east of VERMELLES, until its return to the Corps on February 15th, 1916.

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MACAULAY'S EQUATION.

By LIEUTENANTS E. A. L. GUETERBOCK AND P. R. ANTROBUS, M.C., ROYAL ENGINEERS.

In his very clear explanation of the Macaulay method of solving problems on deflections of beams, Captain Womersley mentioned the case of an intermediate couple applied to a beam.

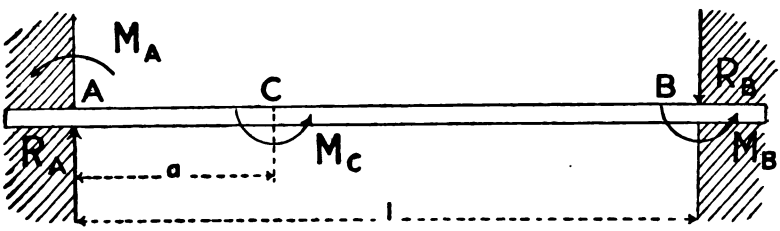

FIG. 1.

The solution by converting the couple into a pair of equal and opposite infinite forces acting at an infinitesimally short distance apart, involves rather long equations which appear to have led Captain Womersley into an arithmetical error in his Example III.

The following is a slight modification of the method which may be found useful in solving this particular problem. It follows so directly from the Macaulay method that many will no doubt be prepared to accept it without proof, but in order to satisfy the most particular, a separate proof is given.

Consider the Fig. 1 above. Take A as origin and the undeflected centre line AB as x axis, and the axis of y downwards.

Using Capt. Womersley's notation, the Bending Moment equation from A to C is :—

$$-EI\ddot{y} = R_A x - M_A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

which gives the slope equation on integration :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x + \alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

and the deflection equation on further integration :—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} + \alpha x + \beta \quad \ldots\ldots\ldots\ldots \quad (3)$$

where α and β are constants of integration.

From C to B the Bending Moment equation is :—

$$-EI\ddot{y} = R_A x - M_A - M_C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

which gives the slope equation :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C x + \alpha_1 \quad \ldots\ldots\ldots\ldots\ldots \quad (5)$$

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Now this equation may, by simply altering the constant of integration, be re-written :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C(x-a) + \alpha_2 \quad \ldots\ldots\ldots \quad (6)$$

from which we derive the deflection equation :—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} - M_C \frac{(x-a)^2}{2} + \alpha_2 x + \beta_2 \quad (7)$$

Now when $x = a$, (2) and (6) should give the same value for the slope of the beam, and (3) and (7) should give the same value for the deflection and thus it will be seen that :—

$$\alpha = \alpha_2 \quad \text{and} \quad \beta = \beta_2$$

Hence the equation (4) can be used as the Bending Moment equation for the whole beam provided that the term $-M_C$ is left out when x is less than a, and the integration carried out in the manner shewn in (6) and (7). Such terms may be enclosed in special brackets.

As a further reminder that equation (4)

$$-EI\ddot{y} = R_A x - M_A - M_C$$

must be integrated in the form :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C \left\{x-a\right\} + \alpha_2$$

it may be written :—

$$-EI\ddot{y} = R_A x - M_A - M_C \left\{x-a\right\}^\circ$$

which clearly makes no difference since $\left\{x-a\right\}^\circ = 1.$

It may be suggested that this is a trick method, but this is not really the case, as the term $-M_C\left\{x-a\right\}^\circ$ is merely a reminder, firstly, of the method of integration, and secondly, that the term is non-existent when x is less than a.

In order to show the advantages of this method, Captain Womersley's two examples are here worked out.

As we have seen, the Bending Moment equation is :—

$$-EI\ddot{y} = R_A x - M_A - M_C \left\{x-a\right\}^\circ$$

Integrating, we have the slope equation :—

$$-EI\dot{y} = R_A \frac{x^2}{2} - M_A x - M_C \left\{x-a\right\} + \alpha$$

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and since $\dot{y} = 0$, when $x = 0$, $\therefore \alpha = 0$

Integrating again we have the deflection equation :—

$$-EIy = R_A \frac{x^3}{6} - M_A \frac{x^2}{2} - \frac{M_C \{x-a\}^2}{2} + \beta$$

and since $y = 0$, when $x = 0$, $\therefore \beta = 0$.

The terminal conditions that $\dot{y} = 0$ and $y = 0$, when $x = l$, give :—

$$R_A \frac{l^2}{2} - M_A l - M_C(l-a) = 0$$

and

$$R_A \frac{l^3}{6} - M_A \frac{l^2}{2} - \frac{M_C}{2}(l-a)^2 = 0$$

These give Captain Womersley's solutions :—

$$R_A = \frac{6a(l-a)}{l^3} M_C \text{ and } M_A = \frac{(l-a)(3a-l)}{l^2} M_C$$

Applied to Example III we have :—

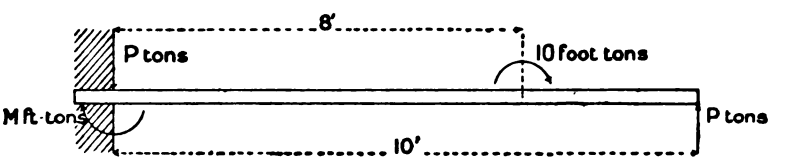

FIG. 2.

$$-EI\ddot{y} = M - Px + 10 \{x-8\}^0$$

whence $$-EI\dot{y} = Mx - P\frac{x^2}{2} + 10\{x-8\} + \alpha$$

and $\alpha = 0$, since $\dot{y} = 0$ if $x = 0$

and $$-EIy = M\frac{x^2}{2} - P\frac{x^3}{6} + \frac{10}{2}\{x-8\}^2 + \beta$$

and $\beta = 0$, since $y = 0$ if $x = 0$

Now $y = 0$, when $x = 10$, hence $0 = M\frac{100}{2} - P\frac{1000}{6} + \frac{10}{2} \cdot 4$

i.e. $50P - 15M = 6$

And $\ddot{y} = 0$, when $x = 10$, hence $10P - M = 10$

Whence $M = 4.4$ foot-tons and $P = 1.44$ tons.

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A "SPORTING LECTOR."

By MAJOR A. V. T. WAKELY, M.C., *p.s.c.*, R.E.

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" 'Unting is the sport of Kings, the image of war without its guilt and only five and twenty per cent of its danger."
R. S. SURTEES.

THIS short article is rather a collection of anecdotes than an essay of literary or educational merit. The title itself is misleading. It is borrowed from that very fine sportsman, Mr. John Jorrocks, and I can never see myself getting up on the platform in canary-coloured shorts and giving forth in the inimitable style of our friend. On the other hand, I think that some of my experiences and deductions may be of interest and possibly of value to the majority of young officers who read the *Royal Engineers Journal.* Further, I am presumptuous enough to think that my remarks may contain one or two points which some senior officers have not thought of before.

It is hardly necessary to dilate upon the general advantages of fox-hunting as a recreation. Half an hour spent with John Jorrocks will tell the reader all there is to know about hunting as a pleasurable and health-giving occupation. The advantages of hunting as an aid to the training of officers are not so well known, and the object of this little article is to try and point them out, and to show how one can use hunting as a training ground for real soldiering—that is, for war.

As the result of many years' study of hunting, I have come to the conclusion that there is no sport in which the necessary qualities of an officer can be developed and trained like they can in hunting. Let me be more definite, and let me state what some of these qualities are. A few of the more important are capacity for rapid decision, military knowledge, powers of observation, smartness and neatness of turn-out, and tact and a knowledge of human nature.

Rapidity of decision is, perhaps, one of the most difficult things to practise in peace time, but in the course of a day's hunting one will get many opportunities. Every time a fox breaks cover the opportunity occurs. Now, before one can come to a decision one has to " appreciate the situation." In tactics lectures we hear a lot about this, and the phrase is associated in our minds with tactical schemes. Let us put these away for a moment, and consider an appreciation of the situation when we hear a " Tally ho !" from the far end of a big covert.

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What is our object and what are the factors? Our object is to see the hunt, to get as near hounds as possible and to stay there. Let us suppose we are on a horse that can jump. There is a fence, perhaps a big one, not twenty yards away. There may or may not be a gate; if there is, there will also be fifty or a hundred people converging towards it. There may be a good scent and hounds may be likely to run fast. We have to decide whether to jump the fence or go for the gate. Is our horse able to jump the fence? Is it necessary to do so? These are a few of the factors. But the chief factor is that of time; generally we have four seconds in which to make up our mind and act. Instant and decisive action must be taken or else we will lose the hunt. Now, in the hunting field such decisions must be taken many times in a day. They arise in many different forms, and the above is only an example. Is there any doubt as to the value of such training to a soldier? Indecision at this moment communicates itself to one's horse. If we take the fence in an indecisive sort of way, a fall is almost a certainty, and, what is worse, both the rider and the horse know that a fall is, to say the least, a likely eventuality. If we go for the gate in a half-hearted way, wavering between the fence and the gate, we will get left and will see no hunt.

I was discussing this very question not so long ago with an officer who went well with the Staff College Drag. He said that every time he was in two minds he got into trouble—a fall, or at best a scramble. This officer had never ridden to hounds before he went to the Staff College, and he had not realized that what passed in his own mind instantly communicated itself to his horse. Any lack of decision was heavily penalized. I noticed some days after our conversation that he was in the first half-dozen up at the check, and he continued to occupy one of these places on every drag day. This was a remarkable example of will power and decision. Is there anyone who can say this was not good training for an officer's work? Make no mistake about it, any lack of decision on the part of a platoon commander in war, and even in peace training, instantly communicates itself to the men. They feel they are being badly led; they waver, they hesitate and are lost. The moral of it is to train one's self to make quick decisions. Whether these be right or wrong, if they are acted upon with rapidity and with energy they will generally turn out all right.

Hunting provides opportunities for training yourself in acting quickly and in adapting yourself to rapidly changing conditions, and there is just the spice of danger there to sharpen your wits. One very seldom gets a quick thing in the routine of everyday life, but it happens frequently in war. You can get it any day in London if you try to cross Piccadilly Circus during the rush hours, but you don't get so much pleasure out of that as you do out of

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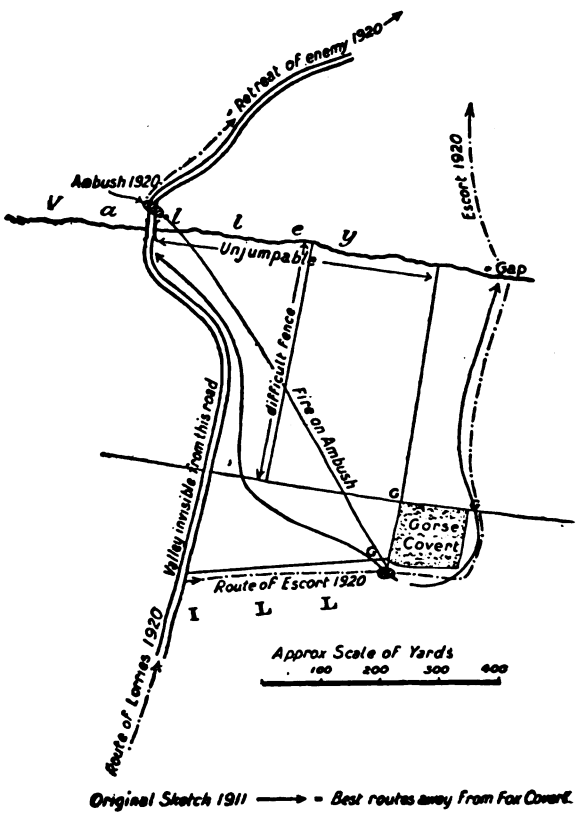
hunting, and there is great and unnecessary danger! I prefer hunting!

Military knowledge covers a very wide scope, and it is at first sight difficult to see how hunting can help. But, to take only two examples, the use of ground and map reading can, I think, be regarded as quite essential parts of one's military knowledge.

Now, it is a fact that in hunting one covers more ground in one day than in the case of any other sport. So the opportunities for the study of ground are endless. You should always take a map with you out hunting, and you should always watch where you go and be able after the day to mark up your itinerary on the map. This teaches map reading as nothing else can. The use of ground can and should be studied. What ground can you push along over, and where must you take a pull at the horse? How can you cut off a corner to save your horse or to get nearer to hounds as they swing?

I heard, not so long ago, of a very remarkable incident showing how hunting taught the use of ground. A brother officer and myself in 1911, having nothing special to do, made a reconnaissance of nearly every fox covert in Kildare. We found the best line away



Original Sketch 1911 ——→ = Best routes away from Fox Covert.

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from the coverts in every direction, the easiest places to jump the fences, and the exact position of gates and gaps. We made little sketches of the places, and discussed them in the evenings. The information was absolutely invaluable during the whole of two subsequent hunting seasons, but there was a sequel.

A road ran about 300 yards from a certain covert. The covert was on a hill, and the road, after dropping the hill, crossed a very narrow valley. Owing to the conformation of the hill, the valley was invisible from any point higher up on the road, but the road and the whole valley could be plainly seen from the covert. The bridge in the valley was therefore an ideal spot at which to lay an ambush to catch lorries coming down the road. In 1920 my brother officer had to send escorted lorries along this road. He told the escorting officer that he had carefully reconnoitred this particular spot out hunting some years previously, and that he considered it an ideal place for an ambush. So he told the young officer to get his escort out of the lorries, just short of the covert, go up to it, and have a look down in the valley. Sure enough, the Sinn Feiners were there, lying up for the convoy! The young officer was not slow to act, and he scuppered practically the whole lot. Here is an instance where hunting knowledge probably saved several lives.

If you are keen on riding and hack out to nearly all the meets, you will get plenty of practice in map reading. Personally, I make it a rule to know every bridle path and track within hacking distance of my station. When riding, I eschew motor roads like the plague, and make full use of all tracks in the country. I had an instance of this only a few days ago. A friend and I had to hack about eight miles home after hunting. He proposed going the main motor road, but I was able to lead him by sand-tracks, and he did not know where he was until we got within a mile of barracks. It is, of course, far better for horses to take them along soft tracks instead of tarred roads. Some months ago I brought another friend home from another direction, along tracks he had never been, although he had hunted in the district for twelve years. It is appalling to think of the amount of hard road work done by such people's horses for no reason whatever, except that they never use a map. I learnt the tip from an Irish doctor many years ago, but he always included three or four banks and a few timber stiles in his ride home. Such a ride home is invariably pleasant, but it is not to be recommended as far as one's horse is concerned after a heavy day's hunting.

On another occasion, as a very junior subaltern, my knowledge of the country round barracks stood me in good stead. I was suddenly detailed on parade to lead an infantry brigade on a night march across open country, and I regret to say I had not practised marching on a compass bearing by night, and did not feel very confident about it. Fortunately, the point we had to get to was very near a fox

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covert two or three miles away, and as I had ridden to it several times and studied the best route on the map, there was no difficulty in leading the troops to the spot without the help of any compass.

The important thing to remember is that you must always bring your map out hunting and use it. I know of countless instances of fellows going miles out of their way because they do not know the country, and will not, for some unknown reason, use a map. If you practise map reading on hunting days you will get very good at it, and some day you will feel yourself quite at home, though the map you hold in your hand be a foreign one.

Smartness and neatness in equipment and dress are things that much could be written about, but a few remarks only are required here. A meet of foxhounds should be just as much a parade for the young officer as a church parade. It is an insult to the M.F.H. to turn up at the meet in incorrect kit, and it is just as much out of place for an officer to turn up in "ratcatcher" after November 1st as it would be to come to one's C.O.'s dinner party in plus fours! Everyone should wear a top hat and a black hunting coat, and as soon as you can ride well enough wear a pink coat. It is incorrect to wear a bowler hat with a hunting coat, and it is incorrect to wear brown breeches with a pink coat, but one sees these combinations not infrequently in the hunting field.

As regards kit, I had an illuminating conversation with a farmer only ten days ago. This farmer had asked us to be very careful not to ride over his wheat. and he said, "You always see the gentlemen in red coats going round the headlands, and they never ride over wheat, but it's them blighters" (this was not the exact word he used) "in bowlers and trilbies that ride down the middle of my wheat." So don't be a "blighter in a trilby"! And if you do carry a red coat, act accordingly and don't ride over wheat. Incidentally you must learn what wheat looks like.

This brings us to the training of one's powers of observation when out hunting. One could write a complete book about this, and it would include everything about the fox and everything about the hounds and how they hunt. But I will only mention here a few of the more obvious things which at any time may affect the ordinary member of the hunt. Learn what wheat, new grass, and beans look like in winter. Again, watch how people open gates. The correct way is to use the hand that is nearest the hinges of the gate. If you do this, you will nearly always open a gate easily without dismounting. Incidentally it requires quick observation to see whether it is necessary to get down to open a gate or not. Nothing is more annoying to those waiting to get through than to see a man fumbling at a gate which cannot be opened from a horse. Always carry a fairly heavy hunting crop with a thong and a lash. It is essential both to complete your kit and to open gates.

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Locked gates are a nuisance. To break a lock use your stirrup iron. Set the lock with the catch facing outwards and the hinge of the lock against the gate post and then strike the lock just below the catch with the stirrup iron. Three blows delivered in this way will break the strongest lock, while twenty smites not so scientifically applied will make no impression even on a small padlock. A chain usually defies all efforts, so always attack the lock. Remember that you should not break locks unless it is really necessary, but it often is necessary, and I have personally done in four this season, three of them to get the huntsman through. Incidentally, none of them were on farmers' land.

A very good instance of the value of observation happened to me some years ago. We were riding through a big wood with hounds. I was on hunting leave, so it was some fifty miles from barracks. I saw a large pile of timber such as the sappers use for bridging. Six months later I commanded a detachment of engineers doing brigade training within two miles of the same spot. The Brigade Commander sent for me one evening and said he wanted four footbridges made over a river next day to get the brigade across. I had no material to make them, but suddenly thought of the pile of timber, and told the Brigade Commander that the bridges would be ready. There was just enough light that evening to get on a horse and find the owner of the timber. I borrowed what I wanted for the large sum of two shillings. At dawn next day my men fetched the timber, and we had the bridges made by midday.

Tact and a knowledge of human nature are absolutely vital to a modern leader of men, and the hunting field is one of the best training grounds for these qualities. You make many friends out hunting, and there is a camaraderie about fox hunting which is very pleasant when one comes across it, but you have to look for it under modern conditions. You can talk to your General out hunting, while at any other time an officer of such high rank is almost unapproachable, and the thought of an official interview with him, even when one has done no wrong, is quite enough to make one miserable for days beforehand! Meeting senior officers out hunting is an excellent way of smoothing over difficulties, and paving the way for things one may want from them. Again, during one's hunting expeditions one has many chances of making very useful friends. A man in a pink coat can make friends of all and sundry if he uses the coat in the right way. As an instance, though perhaps a very unusual one, I may be allowed to quote from personal experience. Before the war I used to send my horse by rail to hunt some forty miles away, and I made friends with nearly all the station-masters on the line I travelled by. After summer manœuvres I was told to entrain my company at one of these stations in an ordinary passenger train. On arrival at the station we found that the engine drivers

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and firemen had gone on strike that morning, and nothing would induce them to function. There was the train, but no steam up and no engine driver, and there was my company, plus twenty or thirty other passengers, looking at the train. A sapper company usually has three or four people quite capable of driving a loco., and mine was no exception, and we did not like the idea of walking the thirty-odd miles to our destination. The station-master, being a personal friend of hunting days, was not averse to falling in with my suggestion that the soldiers should drive the train, so after a trial run up and down to make sure it could be done we started off. We had two bicycles with the company, and we left these with the station master. We dropped the company at its destination, and the two engine drivers took the other passengers on to their various stations. I never heard how much money they made out of it, but there was a "cap" for them! They subsequently left the train in its stable, and rode home on the bicycles. I may remark that this was before the days when rail movements of troops came to be arranged by the Staff with the mathematical precision which we witness nowadays.

Another aspect of the case is this. A keen officer who can ride has many ways of getting into close personal touch with his men, especially if he is in the cavalry or any mounted unit. He can bring his men out for a ride and can make it interesting and exciting for them. Some years ago, as a junior officer, I had charge of about twenty horses. When in camp in a somewhat wild part of the country I used to mount all the drivers on these horses and tell them to follow me. I chose the line very carefully beforehand, so as to have no trouble with the farmers, and it included banks and small fences of all kinds. The drivers and the horses were soon scattered all over the country, some impounded in fields they could not get out of, and some footing it as hard as they could after their horses. No one ever got hurt, and all enjoyed themselves immensely. Incidentally, the good ones were never very far behind me—in fact, they were uncommonly close at times; but I had a good horse! These rides became a weekly routine, and there was great disappointment if, for any reason, the ride did not take place. Those men would have followed me anywhere.

If you are keen on horses and hunting, you will learn everything about your horse, and you should not leave it all to the groom. The knowledge will be very useful later on. When you go to the Staff College—and you should at any rate try to get there—you will be at a disadvantage if you are entirely ignorant of horse and riding. A Company Commander is a mounted officer, and if you have never been on a horse before, you are liable to cut a sorry figure in front of your men the first time you mount your charger. It is so easy to spot the man who has never hunted. I

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you hunt, these things come naturally to you, and you can learn all sorts of useful things if you have a horse to play with.

Always learn to saddle and bridle and also how to groom your horse. A short time ago I was on manœuvres, and some of us put our horses up in a stable while we had some food in the pub. It was a night show and we were late, so there were no grooms about. My companion was a first-rate horseman, but he hadn't the foggiest notion of how to saddle and bridle his horse! I did it for him. Such a situation should not be allowed to arise!

Then there is the story of the Brigade Commander inspecting candidates who had applied for permission to enter for the Staff College examination. You require a riding certificate for that. The Brigade Commander made everyone take their saddles and bridles off and put them in a heap in the middle of the riding school. He gave them five minutes to put everything on again, and not one of them could do it under half an hour! He failed the whole lot! One of the victims himself told me about this.

Another thing to learn is how to catch a loose horse. This is an invaluable trick in the hunting field, but it requires practice. The tip is always to turn towards the loose horse and ride him on your off side and on his near side. The trick was useful to me on manœuvres recently. The General had given his horse to a soldier to hold, and the boy let it go. I was the only one actually mounted at the time, and at once started off in pursuit. It was quite a good ride, and I got the horse after a mile gallop.

I have tried to give above a few instances of the value of hunting as training for officers. But it may be argued that it is not every officer who can afford to hunt. Hunting for the civilian is undoubtedly an expensive amusement, but there are many ways in which the soldier is helped. There is now no difficulty in getting a horse, as a scheme exists whereby troop horses can be hired at 15s. a month, including 4 lb. of oats extra a day. Total cost of the horse is about 25s. a month, if you can share a soldier groom. Most people spend that on cigarettes alone. Then there is your hunt subscription, the most important part of the expenses. Most hunts are very good to soldiers, and at Aldershot we have the Hunt Club. You get the choice of five packs for about £6 6s. per horse for the season. It works out at about 4s. or 5s. a hunt, less than your fare to town! You won't spend much more than the 5s. each hunting day, while, if you go to town every week-end, goodness only knows how much you won't be let in for! And can the pleasure and the value of the two types of amusement be compared? To me it is sacrilege to attempt to do so, therefore I won't try. Kit is certainly expensive, because, as I have already remarked, it must be good. A good saddle and bridle are essential. These will cost about £13, but you can get a good second-hand saddle for £4 or £5. Never

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go out in a military saddle, it looks too appalling for words, and never in a bridle with the reins buckled on! Your clothes, if new, would cost about £40, as you must have "ratcatcher" kit for the Drag and for hacking, and proper kit for fox hunting. You can, however, get very good second-hand hunting kit from a well-known outfitter near Covent Garden, but you must have your breeches made for you by a good tailor. The best way is to get your hunting kit gradually, and in any case most tailors are fairly long-suffering individuals! If you get good kit to begin with, it will last at least twelve or fifteen years, and the best is not dear in the long run.

Another point worth mentioning is that one should always bring out a supply of small change on hunting days. A sixpence for opening a gate does a lot of good and makes hunting popular with the foot people. If a farm labourer catches your horse his services are dirt cheap at a bob, and he goes away delighted. The "wreckers" of Meath have not, so far as I know, their counterpart in any other hunting country. The methods of these gentry are sheer robbery. I remember one wretched man whose horse got into a place known as the "Poor House Drain." They couldn't get ropes round him, but the horse could just move down the drain, so they dug a ramp for him at an angle to the direction of the drain, so that he could walk out. For this they charged £1, the usual fee for their services! But the man didn't manage his horse properly, and the animal went past the ramp and got into such a position that he could neither move forwards nor backwards. He had to be dug out again, and the wreckers wouldn't start work until another sovereign had been paid. An expensive day's hunting! Fortunately, such disasters do not often happen to the average rider to hounds.

The Editor will get impatient if I write much more! In conclusion, I would urge upon any Commanding Officers who may chance to read these lines that hunting should be treated as part of an officer's training, and that those who are keen should be encouraged in every way to go in for it. That hunting is so regarded in high quarters is not open to doubt, and long may such a state of affairs continue. I would also urge upon senior officers that it is up to them to show young officers how properly to use hunting as a training ground. The great value of hunting is lost if the opportunities given by it are missed for want of telling what they are. If this little article is successful in pointing out how hunting can be used, its object will be achieved.

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Brigadier General A. Graham Thomson, C.B., C.M.G., D.S.O.

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MEMOIRS.

BRIGADIER GENERAL A. GRAHAM THOMSON,

C.B., C.M.G., D.S.O.

GRAHAM THOMSON, the son of Surgeon-Major-General Thomson, Honorary Physician to Queen Victoria and King Edward VII, was born in February, 1858, and was commissioned, R.E., in January, 1877.

In 1879, as 1st Lieut., he joined the 17th Fortress Company at Aldershot and proceeded to Malta the following year, where he made his mark in work and sports. He was one of the R.E. Officers' Team which beat the combined Garrison at Association Football; and one of the three 17th Co. Officers who beat all comers at Water Polo. He became a useful Polo player, and had an unusually good barb which he ran in the Races.

At the outbreak of the Egyptian Campaign his Company, being the only R.E. immediately available, accompanied the troops, making the first landing at Alexandria early in July, 1882; and after varied work there and at Ramleh they were among the first troops to be landed at Ismailia. Here for a time he acted as A.D.C. to the C.R.E.; but rejoined his Company when it was called to accompany the Cavalry at the Front. He was present at the battle of Tel-el-Kebir, receiving Medal with clasp and Bronze Star.

At Cairo he was in charge of large working parties of Egyptians improving and remodelling Barrack accommodation, and being essentially just and firm he proved himself the very man for the post. Later, he returned to Malta to bring out the heavy baggage to Abbassiyeh, where, during the trying cholera scourge, he was ever cheery and helpful.

In June, 1884, the 17th Co. left for Suakin to make preparations for the coming campaign, under war conditions, for the enemy were all round Suakin and the Company had to look out for itself.

Here was strenuous work of most varied kinds to be pressed forward in intense heat: ship piers, boat piers, hutments, blockhouses, water supply, light railway, mines, etc.; and here he was equally successful with the native labour parties as he was with the Egyptian.

He was present in the actions of Hasheen and affair at Tamai

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and with his Company and the Scots Guards held the farthest advanced post of Tambuk on the line to Berber.

On returning to Suakin from home in June, 1885, a crowd of Thomson's old working parties clustered round him with every manifestation of delight at seeing him again—and, indeed, they had a name of their own for him.

Mentioned in Despatches, gaining a clasp, Thomson received the brevet of Major for his Services, immediately on his being promoted Captain.

In November, 1885, Thomson went to the Ordnance Survey until the end of 1890; but as a charming instance of his affection for his old Company, then at Aldershot, he asked to join it in its annual fieldwork course in camp and to do duty as a subaltern, which he duly did, as it was short of one subaltern.

Malta saw him again from October, '91 to December, '96, when he went to the I.G.F's. Office. Thomson served in the South African War from November, 1899, to August, 1902; and at the very unhealthy station of Komati Poort started the first blockhouses of thick sand-bag walling and steel loopholes, and stuck to his work in spite of suffering seriously in health. He took part in operations, as a C.R.E. of Division, in the Orange Free State, including the actions at Vet River and Zand River; also in the Transvaal, including the action at Belfast; and also in Cape Colony, south of the Orange River.

Mentioned in despatches, Brevet of Lt. Col., Queen's Medal with 5 clasps and King's Medal with 2 clasps.

From January, 1903, to April, '08, Thomson was very happy and successful with the Training Battalion at Chatham; and King Edward expressed great satisfaction at all he saw at his inspection.

As Commandant R.M.A., (now substantive Colonel) from September, 1908, to September, 1912, he devoted himself wholeheartedly to the Cadets, knew them all personally and took the keenest interest in their work and play: he procured a new football ground for them and saw it in use before he left. Ever assisted by his devoted wife, Mrs. Thomson, he gave constant parties to the Cadets, and they left a truly pleasant memory behind them.

Thomson went to France, immediately on declaration of War, as Commandant L. of C., and served there till October, 1917, having the rank of Temp. Brig. General from May, 1916; but he had to come home, owing to a serious breakdown in health. However in February, 1918, he went to Holland for a year in command of our Prisoners of War there, and his unfailing courtesy and kindness were greatly appreciated: indeed, the British Minister at the Hague wrote thanking him for his good work and saying what a great help he had been in bringing about friendly relations between the two countries.

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Mentioned five times in despatches, gained 1914 Star and Clasp and C.M.G. He had received the C.B. in 1911.

After retirement in February, 1919, the Thomsons lived a good deal abroad, and in Scotland, but he continued to take active interest in the disabled and invalid soldiers, taking pleasure in doing what he could for them.

He died suddenly after a long illness at Vevey at the age of 68, leaving a fine record of work ably and cheerfully done, and the memory to his many friends of a charming character—unselfish, modest, and ever loyal.

E.W.

BRIGADIER GENERAL E. A. T. TUDOR, C.M.G.

ERNEST AUGUSTUS TUDOR TUDOR, who died after a short and sudden illness at Waverley Court, Camberley, on 6th November, 1925, was born at Weston-super-Mare, in April, 1865. He was educated at the Royal Naval School, New Cross, and entered the R.M.A. Woolwich in September, 1882. The course at Woolwich had recently been reduced to two years and, in 1884, after winning his cap in the Rugby XV, he became Senior Under Officer and, in July, on gaining his commission in the Corps, he received the Sword of Honour from the Duke of Cambridge. On completing his course at Chatham he was posted to the Submarine Mining Service and served at home till 1889, when he went to India and took up submarine mining work in Bombay. Here he contracted a very serious illness and was for a long time unable to resume his duties. During his convalescence he visited Hamilton, in Canada, and met his future wife, Miss Edna Sanford, whom he married at St. George's, Hanover Square, in 1898. Meanwhile he had done a tour of service at Mauritius and later he served at Hong Kong, Capetown, Halifax, and other places. He was promoted Colonel shortly before the outbreak of the Great War and was appointed Chief Engineer of the 2nd Army, Central Force, Home Defences, and Chief Engineer London District; afterwards going to France as a Chief Engineer with the rank of Brigadier General. He remained in France until after the Armistice and was mentioned in Despatches and received the C.M.G.

He retired in 1920 and settled at Camberley, and during recent years took a very prominent part in all local activities. He was Assistant Commissioner of the St. John Ambulance Brigade, County of Surrey, and Hon. Secretary of the St. John Ambulance Association County Centre and Assistant County Controller of the V.A.D. under the War Office scheme, also President of the Camberley and Frimley Branch of the Unionist Association. He left three

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daughters, one of whom is the wife of Flying Officer E. D. H. Davies. His sudden death came as a shock to a very wide circle of friends. He was universally popular, and in his young days and before his serious illness, a man of great energy bent upon getting the utmost out of his life and opportunities.

BOOKS.

THE HISTORY OF THE UNITED STATES ARMY.

By MAJOR OF INFANTRY W. A. GANOE, U.S. ARMY (D. Appleton & Co., New York & London, 1924.)

The history of the development of the American Army, from its birth during the War of Revolution (1775) to the Great War, is of great interest to British readers in that the author describes without reserve the difficulties which confront the military authorities of a nation which will not tolerate universal service nor pay for an effective voluntary army in times of peace.

In Vol. III of the *Letters of W. H Page*, the American Ambassador in London during the Great War does not mince matters when he writes of John Bull "muddling through," and discusses the extravagance and waste due to Great Britain's military system. Major Ganoe's volume shows that "muddling through" must be a characteristic of the Anglo-Saxon race. The United States, however, learnt their lesson, and as Mr. Page writes in a letter to President Wilson: "The prompt passage of the conscription act opened their (British) eyes to our earnestness and efficiency more than any other single event."

The story of the United States Army is one of constant struggle with Congress. It came to such a pass that even when, in the face of imminent danger of war lightheartedly entered into, Congress voted for an increase, sometimes on a lavish scale, it simultaneously enacted a law providing for the reduction of the army to its former numbers on the cessation of hostilities! The danger past, there was heard at once the ever-recurring cry for Economy.

"Economy is certainly a very high political virtue, intimately connected with the power and public virtue of the community. In military operations, which, under the best management, are so expensive, it is of the utmost importance; but by no propriety of language can that arrangement be called economical which, in order that our military establishment in peace should be rather less expensive, would, regardless of the purposes for which it ought to be maintained, render it unfit to meet the dangers incident to a state of war."

So wrote Mr. Secretary of War Calhoun in 1820, in resisting the usual cry from Congress for the reduction of the army. Nevertheless the army, which at the end of the second war with Great Britain had an establishment of 62,000 and a strength of 30,000, and had been reduced in 1815 to 10,000 men and "a Corps of Engineers," was further reduced to only

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6,000 men. The condition of the army before 1812 is bluntly described by Lieut. Colonel William Duane (author of a *Handbook for Infantry*, 1812) as follows :—" There is no discipline ; there is even no system ; and there are gross misconceptions on the subject. There appears to have been a disposition to discourage the acquisition of military knowledge."

What was the result of this apathy ? Major Ganoe gives the answer. " During the years after 1812, the army tried to bring itself out of the ignorance and decadence into which it had been tossed after the Revolution. But the only civilians who knew the army's work and understood the nation's need were a limited few like Calhoun. Politics did not know, need to heed nor care to consider the necessity for fighting men. The farce of 1812 had made little impression upon the general public. We had come out all right—that was enough. Just why or how we had ' come out ' was a matter of little concern. That with 527,654 so-called soldiers we had been unable to defeat not over 5,000 British Regulars, that for two years and a half so small a hostile force had brought devastation within our borders and had killed and wounded 5,614 Americans, and that our nation had uselessly spent for all this discord of training over $50,000,000, had not come to be realized by the voter. He was developing the inside of the country without much thought of its edges. It was too much to expect 7,000,000 people to support 10,000 soldiers."

History repeated itself for the next 100 years.

The war of 1812 was long forgotten before the Mexican War of 1846. In the public eye up to that time, and even for years after the Civil War, the Army only existed to drive back the Indians and suppress labour strikes.

The lessons of 1846-8 were ignored, by the Federals at all events, in 1861. It took President Lincoln two years to find, and trust, General U. S. Grant. In the meantime he and his Secretary of War committed every mistake that was possible in their direction of the Army. Had they given General McClellan, who was a good soldier, as free a hand as President Davis (a graduate of West Point) gave to General Robert E. Lee, numbers alone would have told, and the Civil War might have been over in a year.

The accumulated experience of previous wars, to say nothing of the Franco-German war of 1870-1, though it all had been carefully collated by Major General Emory Upton in his report on " The Military Policy of the United States," after a tour of investigation in Europe and Asia, was all forgotten or ignored when the United States found themselves at war with Spain in 1898 ; and, according to Major Ganoe, the situation on the Mexican border was not much better in 1914-16. He writes : " For the third time in 3 years, a great nation of over 100,000,000 people presented a spectacle to the world of being unable to assemble even the semblance of a powerful force. General Funston's predicament (at Vera Cruz) was all the more pitiable when it is considered that, had he received an order to journey in the same path that General Winfield Scott had followed 70 years before (to Mexico City, in the first Mexican War) he would have found that he could not budge for lack of men and transport." The Regular Army actually numbered only 24,000 men in 1914, a smaller strength than at any time since 1861, and this in spite of the great reforms initiated

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by President Roosevelt and his able Secretary of War, Mr. Root, in 1903-1904, after the Spanish War, the American participation in the International Expedition to Pekin, and the Filipino Insurrection.

The last chapter brings in the Great War, and is the most interesting. It describes the steps taken, but not for a year and ten months after the outbreak of the Great War, to increase the army—on paper—gradually to about half-a-million men in case of the United States becoming eventually involved, and the hurried legislation consequent on that event occurring on April 6th, 1917. Fortunately for the United States—and for the Allies—Congress still had time to put its house in order while the Allies bore the brunt of the German pressure. Thanks to Mr. Root's creation of the General Staff, and to the advice and information placed at its disposal by the Allies, Congress was able to act promptly and effectively. This time no initial mistake was made. Conscription was adopted at once, and it enabled the training of officers and men to be placed on a methodical basis and run on a proper system from the start. Major Ganoe says: "Our greatest improvement over England's haphazard arrangements was the enactment of compulsory and universal service. That we could profit from mistakes of previous bloody wars by attending to Washington's warnings and Upton's examples, and stamp out the fallacy of voluntary service that had wrecked efficiency in our previous wars, had been a hope too sanguine for military experts to entertain. It is not easy for a nation while fighting for the very essence of democracy to wrap itself round with a garment of autocracy. No greater compliment can be paid to the intelligence of our mixed population than that it was able to perceive the nice distinctions between the harsh means and the noble end. It is possibly the first case on record in our history when we have signally advanced in military policy."

The result we know. All male persons between 21 and 30 were made subject to registration and conscription. (Nominally, the manhood of the United States had always been liable for service). Congress fixed the establishment of the Army at about 1,300,000 men. The Regular Army was to be at once recruited to full strength from volunteers, or if sufficient volunteers were not forthcoming, by conscripted men. The pay of all forces, regular, militia and conscripted was to be identical, and the whole army was to be governed by the regulations governing the regular army. All officers above the rank of Colonel were to be appointed by the President, with the advice and consent of the Senate, instead of being appointed by the various States. No person was to be allowed to furnish a substitute. No bounties were to be paid to anyone as an inducement to enlist or re-engage.

June 6th, 1917, was fixed on for "Registration" day. In the meantime, on May 15th, 40,000 civilians, candidates for commissions, had presented themselves for training at sixteen large cantonments ordered to be prepared for that purpose in different parts of the country as soon as war was declared. By a process of elimination about half of these were accepted for commissions on the completion of 90 days' training, about the middle of August. On Registration day, 10,000,000 were registered. The first quota (drawn by lot) of 687,000 men reported for training on September 1st, by which time camps and cantonments had been prepared,

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and officers were available as instructors. It came as a shock to the authorities and the nation to learn that out of a total of 2,750,000 young men examined by the medical authorities, 46.8 per cent. could not pass the physical tests for front-line soldiers. England was not the only home of the C3 class!

By the beginning of 1918, 1,325,000 men had been enrolled, 42 Divisions had been organized, 8 of which were Regulars, 17 National Guard (organized militia of the various States), and 17 National Army. Six Divisions, each consisting of 975 officers and 27,152 other ranks had arrived in France.

In view of the submarine menace sea transport was always the difficulty, but in May, 1918, 130,000 troops were sent to France, and in July 150,000. At the close of the war, almost 2,000,000 men had been transported overseas.

The war did not last long enough for the Americans to test the efficacy of their arrangements for reinforcements, but there is little doubt that once the question of enlistment was solved by universal service the rest was easy. In former wars it had been the practice to take the short view; enlistment was for 3 or 6, or 9 months, and in some cases for a year or longer. The result had been that men were due for discharge as soon as they reached the theatre of war, or even before they could do so. They had to be bribed by bounties and promises of land grants to extend their service or re-enlist. The Regular Army had been recruited under one set of rules and terms of service, while the militia and "volunteer" armies serving alongside of it were governed by different and various regulations both for enlistment and length of service. Towards the end of the Civil War there were many regiments which had been reduced to a mere skeleton through losses and expiration of enlistments, while all the time new regiments with new officers were being raised. Fortunately Great Britain had taken this lesson to heart before the Great War, and the principle of reinforcing existing units instead of raising new ones had been insisted on, and was adhered to even to the extent of disbanding the fourth battalions of brigades to make up reinforcements for the reduced brigades of 3 battalions. But though we had had our lesson in South Africa, our experience there had not impressed itself sufficiently on our minds to make us realize the necessity for universal service before the Great War. Americans cannot now understand why Lord Kitchener did not insist on universal service on the outbreak of the Great War when men were flocking in thousands to the recruiting offices, and the flow had to be discouraged (in September, 1914). This mistake, hastily committed for reasons which at the moment appeared to justify it, took months to rectify. It was avoided by the Americans, thanks to our experience being placed at their disposal through the agency of a clever and popular military attaché—Colonel George O. Squier.

A good deal is said about the U.S. Military Academy at West Point. It was originally founded for the education of the engineers only, but became a training school for aspirants to all the arms, like Addiscombe for India.

The mention by Major Ganoe of the foundation of the Army Signal School at Fort Leavenworth, Kansas, in 1905, reminds one that the original designation of the Royal Corps of Signals was based, like its initial

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organisation, on the U.S. Signal Corps. (Incidentally, one nowadays sees officers of the Royal Corps of Signals referred to, even in the Press, as belonging to " Royal Signals," surely rather a stupid abbreviation !)

In his chapter on the renaissance of the Army, Major Ganoe mentions the first autumn manœuvres of the American Army, which were held in Virginia in 1904, joint Army and Navy operations having taken place two years previously on the Connecticut coast. The present writer was one of a number of foreign officers present who were taken charge of by a captain of the General Staff specially detailed for the duty. He had the rare distinction of wearing the Congressional " Medal for Valor," the nearest equivalent of our " Victoria Cross," for gallantry in the Philippines. Shortly afterwards he was specially promoted from Captain to Brigadier-General for his services in that campaign. In 1914-16 he, still a Brigadier-General, commanded the American force, eventually amounting to 75,000 men, in the second war with Mexico, or rather with the insurgent bands of the followers of Villa and Carranza which were running riot all over the country and violating the territory of the United States. The operations on the border having fizzled out with no definite result, in June 1916, the Commander was available when the United States broke off relations with Germany. As Commander-in-Chief of the American Expeditionary Force, General Pershing—for he it was—achieved a record, in that he was the first man ever allowed by a President of the United States, who is the Commander-in-Chief the Army of the United States *ex-officio*, to remain in command of an American Army throughout a campaign !

At Manasses, in 1904, he was described to us as " An outdoor man, a fine leader, but hardly cut out for the office work of the General Staff." Of his achievements, in spite of this supposed disqualification, Major Ganoe says : " All agree that the accomplishments of General Pershing are properly lauded in foreign and domestic accounts. If, as has been said, he did no greater thing than to prevent the infiltration of units into those of our Allies, by his tact and determination, he would deserve all that the public has accorded him. . . . . But he did more, he developed a driving machine that spelled forward movement against the German." All who served alongside of Americans in the war will echo his sentiments.

Major Ganoe's book is written for the American public, and, more fortunate than General Emory Upton's classic report on " The Military Policy of the United States," which was pigeon-holed from his death in 1881 till it was discovered, reprinted and widely circulated by Mr. Secretary Root in 1903, is and will be available for civilians and soldiers to read before the United States embark on another war. It is to be regretted, from the point of view of international amity and the next generation, that it contains not a word of acknowledgment to the Allies, France and Great Britain, for the assistance rendered by them in the organization, arming, training and transport by sea of the American troops. For any record of help from England, it is necessary to turn to Mr. Page or Admiral Sims. Mr. Page, like Colonel House, realized from the outbreak of war that unless the United States came in on the side of the Allies, they would be the next target of the insensate World-Policy of the Germans. He had no hesitation in availing himself of the advice

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and help which England was only too willing to give, and did give through the Embassy, even two years before the United States broke off relations with Germany. Major Ganoe states, somewhat regretfully, that even after a year of war, the American Expeditionary Force had still to rely on French aeroplanes and field guns.

His peroration has its lessons for us. "When a nation begins the business of preparing for war after it has declared it, much waste and much loss must result. Faults arising from the consequent haste are attributable to no single individual. In retrospect the Great War held more that should shame us now. The training of officers and men had to be scant in a number of instances. Future historians of this conflict will reveal that the inexperience and lack of knowledge incident to haste produced in themselves undue loss. Soldiers had to be placed in the line when many of them had not had time to learn the use of the weapon they were handling. Further, the assignment of officers and men to the multifarious duties of a modern army could not be made with sufficient appropriateness in the time allotted. Laundrymen in the ordnance department, engineers in the quartermasters corps (supply), mechanics in the infantry, electricians in the provost marshal general's department, and lawyers in the Signal Corps felt themselves to be square pegs in round holes. Promotion, too, had to be haphazard, when there existed no agencies for the proper classification of officers and men. . . .

"To the degree that a nation is late in its discipline and training, to that degree must the sufferings of the individual be increased. So must the country's extravagances. Vast sums appropriated for materials on the outbreak of war had to be spent when values had risen to many times the height they had stood before 1917, and when it was impossible to get delivery. In the meantime General Pershing lacked many weapons and machines for effective fighting. It took us over a year to get into real offensive against the enemy.

. . . "To cap all, the selective draft (universal service) revealed the fact that almost half of the young manhood of our country was either defective or unfit for fighting. Had a large percentage of our youth had the opportunity of development, best accorded in military camps, and had such exercises been carried on even for limited periods before the war, no one can doubt that this appalling figure (46.8 per cent.) would have been materially reduced. And, in the meantime, the boy would have become more commercially efficient and a more self-reliant citizen."

. . . "When we were strong, disciplined, trained and well organized, we gained a quick peace. When we were not so constituted, we lost lives and money fruitlessly. It was not war of itself that brought so much horror to our people, as did comfortable sleep in the intervals of quiet.

"It would be manifestly unjust to rail at Congress for its seeming omissions. . . .

"If the public wanted anything intensely enough, the law-maker would have to vote for it. If legislative derelictions have been committed, each one of us as citizens of the republic is to blame, unless we have used our powers legitimately to the contrary."

One's memory goes back at once to Lord Roberts and to the patriotic M.P. who some years before the War resigned a safe seat to stand again

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in the same constituency as an Independent candidate favouring universal service, and, unsupported by either of the Great Parties, received 400 votes instead of 4,000! (One sees the proof-reader wondering whether "patriotic" is a misprint for "quixotic."!).

The book contains a fair, but inaccurate, index, and a large bibliography of American authorities on which the author bases his narrative. There are no maps whatever, and it is therefore difficult to follow even the slight sketches of the various campaigns described. A good deal of useful information can be obtained from the tabulated appendices, one of which discloses the amazing fact that Regular troops were employed on 328 occasions in "putting down labour strikes" between the years 1881 and 1895 in all parts of the country. About half of these labour troubles occurred in the last two years after the great financial *débacle* in 1893.

After reading Major Ganoe's candid volume it will be interesting to see the volumes of the American Official History of the Great War dealing with the matters under review.

H.B-W.

CAMP AND SOCIETY.

By THE LATE COLONEL H. M. SINCLAIR, C.B., C.M.G. (Chapman & Hall, price 18/-).

After his retirement from the service the late Colonel Sinclair wrote his autobiography for the benefit of his children and other relatives. His widow, wisely judging it to be of sufficient interest, has now published the volume under the title "Camp and Society," omitting such parts as were matters of purely private concern.

Sinclair was an unusually able man. He passed first into, and out of, the R.M. Academy, and second into, and out of, the Staff College, a specially remarkable feat as regards the R.M.A. because, as he himself says, he was not a good mathematician.

He was a grandson of Sir John Sinclair, Bart. His father, after ten years' service in the 4th Madras Cavalry, left the army, went to Oxford and was ordained. He was Vicar of St. George's, Leeds, where his son Hugh was born in 1855, and in 1857 was appointed rector of Pulborough where he remained till his death in 1878.

In 1865 Sinclair was sent to a private school at Malvern Wells, where most of his fellow pupils seem to have been heirs to peerages, and thence to Repton in 1867. Of this last school he gives a very unflattering account. On leaving he went to Frost the crammer for six months and passed into Woolwich in 1872. He was at the "Shop" with the Prince Imperial, and together with four other cadets attended the funeral of the Emperor Napoleon at Chiselhurst. Leaving in 1874 he was at the S.M.E. till 1876. On obtaining his commission Sinclair was posted to Dover and was transferred to the 23rd Field Co., R.E. at Aldershot in 1877. The following year witnessed the occupation of Cyprus by Sir Garnet Wolseley, with a large British and Indian Force. Sinclair was ordered out to the island in October, 1878, and on arrival at Larnaca took over charge of the works which were being carried out by Indian Sappers and Miners who were returning to India. In Cyprus he remained, with intervals of leave,

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till the spring of 1886, having been for nearly six years Private Secretary to the Governor, Sir Robert Biddulph. The descriptions of Cyprus and the work there are very interesting: still more so are the accounts of trips to Syria and the Lebanon accompanied by Valentine Chirol, then a young journalist, and on another occasion to Palestine.

On his return to England, Sinclair, to his great disgust, was ordered to Athlone, as D.O., where he remained till he entered the Staff College in 1888. On passing out he was, early in 1890, posted to special duty at the War Office on the scheme for the Defences of London, together with Major the Hon. (now Lieut. General Sir) Frederick Stopford and Captain Benson, R.A., for two years. His next appointment was that of D.A.A.G. at York, where he remained three years, and then in 1895 became Staff Officer to the C.E. at Aldershot. In December of that year he went to Ashanti as C.R.E. to the expedition, a bloodless one, returning to Aldershot next year. In November, 1896, he was ordered to India, becoming Executive Engineer, Military Works, at Ferozepore, subsequently Assistant Military Secretary to Sir George Luck, Commander-in-Chief in Bengal, and then, in 1899, A.A.G., Allahabad.

In the winter of that year Sinclair was ordered to South Africa as A.A.G. Transport. His experience in the Boer War was not a happy one. Never given a really responsible appointment, he was moved about from pillar to post, and eventually, after returning to England in 1890, went back to India to complete his tour of service, first as A.A.G., Bombay, and finally as C.R.E., Allahabad. Back in England in the spring of 1902, he was posted to Woolwich as C.R.E. His subsequent appointments were those of A.Q.M.G. at Plymouth, and then Salisbury, and finally Chief Engineer in Scotland. He retired in 1905.

What was probably the most important and thoroughly satisfactory part of Sinclair's work was done subsequently, during the five years he was in command at Longmoor Camp, training Railway Companies for the War.

Whilst on the Staff at Salisbury he married a daughter of Sir John Jackson, the well-known contractor. On his retirement from the service they went to live at Barming House, near Maidstone, which was still their residence when he died.

So much for Sinclair's "Camp" life. The "Society" chapters of his autobiography are certainly not less interesting. He knew more or less intimately a remarkable number of prominent people, amongst others the Duke and Duchess of Teck, Lady Burdett-Coutts, Lord and Lady Granville, Lady Dorothy Neville, Gladstone, Lord Rosse, Lord and Lady Wolseley, Maria, Lady Ailesbury, Henry Irving, and Holman Hunt. Lady Burdett-Coutts was a special friend. Of some of these there are new and good stories. Sinclair had some curious experiences with his acquaintances. When a subaltern in Cyprus he gave an order for a number of wheelbarrows to a small contractor. In after years, he recognized this man as the mysterious multi-millionaire, Sir Basil Zaharoff.

Sinclair was a good linguist. In Cyprus he learnt to speak Modern Greek fluently. This accomplishment stood him in good stead, as, besides being useful to him in his work as Private Secretary, it paved the way to friendships with dignitaries of the Orthodox Church, and opened

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many doors in Cyprus, Syria and Palestine which otherwise would have remained closed to him. When the Venerable Archbishop of Cyprus was presented to Queen Victoria in 1890, at a garden party at Marlborough House, Sinclair was in attendance as interpreter. Moreover, when in India, he passed the Higher Standard Examination in Hindustani within a year, no mean feat.

His death has been greatly regretted in that part of Kent where he lived so long, and took a special interest in Church affairs. Mrs. Sinclair is to be congratulated on the way she has edited the autobiography. Books of this kind are frequently discursive, "Camp & Society," is less so than usual.

W.P.

ELEMENTARY TACTICS, OR THE ART OF WAR, BRITISH SCHOOL.

By MAJOR R. P. PAKENHAM-WALSH, M.C., R.E., *p.s.c.* (Sifton Praed and Co., 1926,) Price 10/6.

The author has given us a book on tactics and organisation which is well worth buying, not only by officers who have been out of touch for some years with active soldiering and require a book to give them a general line to go on before getting down to the detailed study of the official text books—the *raison d'être* of its production—but which will also be of great assistance to a much larger circle of military students engaged in educating themselves and their subordinates for entrance to the only school in which they can complete their education—the school of war itself. It can be confidently recommended to both regular and territorial officers; to the latter it may almost be said that it will be a Godsend.

Before the Great War there was a plethora of manuals, dating from Clery's *Minor Tactics*, Home's *Tactics* and Wolseley's *Pocket Book* to a host of other publications, more or less of the cramming class, written after the South African War; but to no single one of them was it possible for the seeker after knowledge to turn with any confidence of being able either to fill the gaps left by the official text books, or obtain any help in applying the principles therein enunciated.

Major Pakenham-Walsh expressly states that he has no desire that his volume should take the place of the official text books. It is based on them, and with its ample marginal references will be invaluable in studying them.

The book is divided into three parts. In the first, the principles of war and the mechanism of the Army are dealt with. In the second, the theory of application of the principles of war in various forms of tactical operation are considered, showing how the various arms and services are employed towards the attainment of the objective. In the third, certain examples of operations are worked out in detail on the maps provided.

The third part is especially valuable. In working out the schemes, which are of a progressive nature, administration factors are not overlooked, and the co-operation of the air arm, tanks, signals including

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w'reless, engineers and gas service are carefully considered in the combined operations of the three arms.

Each scheme is developed in detail—scheme, orders, narrative and notes—in a series of consecutive problems. These will be found to be very helpful by officers who find themselves faced with the task of preparing tactical schemes for the training of their units, and who are at a loss to know where to refer for the technique of their preparation and their conduct. The author does not overlook the fact that there are probably more solutions than one of every scheme. He says : " For every problem there are probably several ' correct ' solutions. An effort has been made in every case to give a simple solution in agreement with the principles and practice of war as laid down in the official text books of the British Army, and to explain the reasons for the action decided on in each particular case."

There is a brief, but useful, chapter on future developments in war. In the words of the author : " It is the duty of every officer to consider the progress of new auxiliaries, and to foresee how the latter are likely to affect the application of the principles laid down in the text books." He reminds us that : " The surest way to be surprised in war is to imagine that the next war will be like the last."

In conclusion, it may safely be said that any officer who will, after reading the book, take the trouble to work out his own solutions of the schemes and then compare them with those prepared by the author, will have no cause to regret the expenditure of time and the half-guinea at which the volume is offered.

H.B-W.

KEKEWICH IN KIMBERLEY, being an account of the Defence of the Diamond Fields, Oct. 14th, 1899—Feb. 15th, 1900.

By BREVET LIEUT-COLONEL W. A. J. O'MEARA, C.M.G., late R.E., *p.s.c.* (The Medici Society, London & Boston, 1926). Price 7s.

No one is better qualified to write an account of the Siege of Kimberley than Lieut. Col. O'Meara. He was one of the three officers of Royal Engineers who served under Major-General Robert Kekewich throughout the siege, the others being the late Brigadier-General Duncan S. MacInnes, and Lieutenant-Colonel R. L. McClintock. Lt.-Col. O'Meara had been sent out with a batch of special service officers 3 or 4 months before the outbreak of war and had carried out a great deal of valuable reconnaissance work in the Orange Free State. Disguised as a commercial traveller, he had traversed, in a Cape cart or on a bicycle, a large area of country contiguous to the western frontier of the Free State, and, in circumstances of considerable risk to himself, had obtained and recorded a great deal of information which, in the absence of good maps, proved invaluable to the advance of the Western force.

The book is an accurate narrative of events leading up to the outbreak of hostilities, and during the siege—when the author was appointed chief staff officer to General Kekewich. It can hardly be classed as a military history, but it contains much of great value to the military student, in

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showing the difficulties which confronted a British commander in organising the defence of an open town in a country the inhabitants of which were, for the most part, hostile to the British, though they were British subjects. The details regarding the raising and equipping of a volunteer force, chiefly enlisted from the townspeople and employees of De Beers Mines, and the arrangements for organising the food supply of the troops, civil population and natives, are most instructive; while the story of the friction between Mr. Cecil Rhodes and the Defender of Kimberley has valuable lessons for officers who may find themselves in a similar position.

It is the trouble between Kekewich and Rhodes which caused the book to be written, primarily with the object of clearing the memory of that gallant and fearless soldier from the unjust aspersions cast upon it by those who at the time believed that Mr. Cecil Rhodes could do no wrong.

In his introduction, Lt.-Colonel O'Meara explains that he undertook the work mainly because the partisans of Rhodes, immediately on the relief of Kimberley, and at a time when, by the rules of the service, Kekewich was bound to maintain silence, gave currency to statements which grossly misrepresented his conduct towards Rhodes. To quote the author:—

"Those partisans alleged, *inter alia*, that the friction was due solely to Kekewich's tactlessness and the want of consideration shown to Rhodes, who—it was further alleged—had been treated by Kekewich as if he were an 'ordinary citizen.'"

Rhodes apparently regarded the war as a phase in the struggle between himself and President Kruger. The memory of the Jameson Raid rankled in Rhodes' mind. He told Kekewich, in so many words, that his particular ambition was that at the end of the war he should be able to announce that his own personal interests, as well as those others which he represented, had not suffered damage to the extent of one penny piece. Lieut.-Col. O'Meara states that "the real cause of the difficulties was that Rhodes (a Privy Councillor) had, just before he went to Kimberley, obtained information at Cape Town as to the British plan of campaign. He disagreed with it, in that in his opinion it did not give sufficient importance to the 'strategical importance' of Kimberley. He made no secret of his intention to be 'a factor in the military situation,' and to secure a radical change in the foregoing plan, so far as the Western theatre was concerned. As a soldier, Kekewich could not, and would not, aid and abet Rhodes to force the hands of the military authorities. This was Kekewich's great offence in Rhodes' eyes. One day, in his anger, he shouted at Kekewich: 'You damned soldiers are so loyal to one another that I verily believe that if God Almighty even was in a fix, you would refuse to get Him out of it should the doing so interfere with your damned military situation.'"

The truth was that Rhodes was himself the almighty god in a fix, having been caught in Kimberley by the outbreak of hostilities on his way to Rhodesia. He was trying to move heaven and earth to find a way out of the dilemma in which he found himself.

There never has been—nor will there be—any doubts in the minds of those who knew General Kekewich personally, that tactlessness, or obstruction by vindictiveness had any part in his character.

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Can any excuse be found for Rhodes' conduct? Looking back to the slump in the training of the army before the South African war awoke us out of the sleep of a long peace, one realizes that it was not only the Army which was in fault. The civilian population and its political leaders had not been trained to realize that a knowledge of military affairs is as necessary to the nation as to the army. There had been an awakening in the army, thanks to Lord Wolseley, and this awakening had spread to the Staff College under General Hillyard, amongst whose pupils most of the Army Commanders and Chief Staff Officers of 1914-18 are numbered, but it had still to spread through the army. The nation had forgotten all about war.

It is not, perhaps, surprising to find a man of the calibre of Mr. Cecil Rhodes fretting at the restraint in which he found himself fettered within the perimeter of the Kimberley defences. There he was regarded as a god. The whole of the huge organisation of the De Beers Diamond Mines looked up to him as their chief. It was they who supplied the personnel for the greater part of the volunteer garrison, as well as the material for the defence, and it must be acknowledged that had it not been for De Beers the defence of Kimberley would have been a far more difficult proposition than it was.

On the other hand it is, perhaps, fortunate that Mr. Rhodes was confined in Kimberley, and that his unwilling custodian was a man like Kekewich. Had he been free to exert his dominating will on weaker men either at Cape Town or in Rhodesia, or in London, the effect of his interference in military affairs, of which he knew nothing, might have been disastrous.

As soon as communication with the outside world was cut off, Rhodes came up against the Commander and his staff. He endeavoured to communicate with Cape Town and, through Cape Town, with London, by using his own runners, and, although Kekewich offered to assist him to send his messages through official channels, he repeated the offence, and was found out. He then interfered with the censorship, and boasted of it. Incidentally, he tried to induce Kekewich to carry out an operation which was obviously impracticable and unsound. Naturally he failed, and he resented it. He ought to have been court-martialled. No man could have done more to try to keep on good terms with Mr. Rhodes than Kekewich did. Throughout he showed remarkable self-restraint.

This trait of Kekewich's character was subjected to an even severer trial on the relief of Kimberley. That he was not *persona grata* in certain quarters, and the reason for it, are known to a few. Rhodes and his supporters found fertile ground to sow the seed which widened the breach, with the result that Kekewich was not given a command for a considerable period. Lord Kitchener put matters right, and officers who served in his column in the Northern Transvaal will bear witness to his success as a commander in the field.

Kekewich and his staff officers received one acknowledgement of their services to Kimberley. It is not mentioned in the book. The owner of one of the few " claims " in the diamond mines not already absorbed by De Beers, presented each of them with a valuable uncut diamond found in his claim during the siege. He was a German. Not a word of acknow-

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ledgment did they get from De Beers or its chief for saving their property.

Kekewich felt it all very deeply, but he never uttered a word of complaint of his treatment at the hands of Rhodes, and his lips were sealed to his dying day. It is quite time that his memory should be cleared of any suggestion that he was in any way to blame for this unfortunate episode. Lt.-Col. O'Meara has carried out his self-imposed task with great restraint, for he has not recorded all that is known of the behaviour of Rhodes and those others who did their best to ruin Kekewich's career.

Sir Robert Baden-Powell has written a foreword to the book which is worth quoting :—

"A clever brain, a human heart, and a cheery spirit, a lovable disposition, unswerving loyalty, and absolute devotion to duty—supply a make-up for a man which should carry him through most, if not all, of the difficulties of leadership in life.

Robert Kekewich possessed just these qualities in a remarkable degree."

* * * *

"In the event he pulled through successfully, and thus his character and his methods are well worth studying by those who aspire in their turn to happy and successful leadership."

The volume should be read, and readers will have the satisfaction of knowing that the whole of the proceeds of the sale of the book are to be given to the "Past and Present Association" of The Buffs, General Kekewich's regiment, in aid of the regimental charitable fund.

H.B-W.

MILITARY ENGINEERING.

(TECHNICAL TRAINING. VOL. I: MECHANICAL ENGINEERING, 1925). 364 + XXIV pp. 94 plates. 3/6 net. (H.M. Stationery Office).

THE subject of this War Office Manual is of national importance, and of special interest to Military Engineers. The changed conditions of modern warfare have brought Mechanical Engineering into prominence as a vital factor in military operations; from the first outbreak of hostilities, it became generally recognised that the Great War was an engineers' war. This truism was so firmly established that the re-statement of the fact may seem redundant, but in some arms of the service the subordination of the technical officer under regimental or administrative commands would still appear to require re-adjustment. In the senior Service the lessons of war have already been so far forgotten that a recent Fleet Order has entirely deprived Engineer Officers of Military status without giving them the equivalent executive rank enjoyed by their brothers on the Quarter Deck. Representatives of six leading Institutions, speaking on behalf of some 40,000 professional engineers, are exerting their claims for the re-establishment of the more cordial relationships of equality granted to the engineers of the Royal Navy, early in 1915, as a reward for their meritorious service.

If it is admitted, as it must be, that the war was an engineers' war, then too much attention cannot be given to the efficient training of engineers,

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and it is generally considered that to be efficient in Mechanical Engineering it is essential that a prolonged course of practical training in the workshops should be aimed at, as well as sound technical education. Practical processes are still felt by some to be unsuitable for description on paper, but the mass of text-books and of articles in the technical press bears evidence of an undoubted demand for such literature. It, however, cannot fulfil its *raison d'être* if used as a *substitute* for the workshop practice, but, as a *supplement*, it may be of the highest value in assisting the young engineer to a real understanding of the plant and materials with which he is brought in contact.

So much for the importance of the subject; now to come to the book under review. This is a work upon which much care in selection and abbreviation has been expended, and is in itself a *vade-mecum* of the Military Mechanical Engineer, and it should save him the outlay of quite a small library of text-books on the various aspects of his work, whilst its cost is less than that of any one privately issued text-book.

It is written in clear language and in condensed form, without employment of higher mathematics, and it is illustrated by numerous line drawings of typical examples, but does *not* include working drawings to scale. The condensed arrangement has naturally limited any effort at literary style, and explicitness may sometimes have been sacrificed on the altar of brevity, but, on the whole, the rigorous exclusion of all redundant matter renders the work suitable for the class of readers for whom it is designed and by whom it will be welcomed.

To outline its contents—the volume presents concisely the practice and contents of the workshops, giving little theory, and consequently does not treat of the rudiments of mathematics, mechanics, strength of materials, etc., to any extent, although these are all of importance to mechanical engineers. Part I takes the reader on a visit to the workshops and describes the machines contained and the operations carried on therein. Part II treats of heat engines, describing various types of prime movers, auxiliaries, fittings and their installation, erection and testing. Part III is somewhat obscurely described as "Application," and deals with transmission of power, gearing, bearings, shafting, and general millwrighting.

Such is the outline; the contents will now be considered in some detail, but it may be remarked in passing that this book on mechanical engineering has nothing to say on such matters as railways and locomotives, pumps and water impounding machinery, refrigeration, conveyors, elevators and cranes, steam turbines, marine engines, automobiles and aeroplanes (except as regards petrol engines); yet all these are aspects of the subject which even military engineers cannot overlook and a knowledge of which is required at times—times of emergency only perhaps, but such occasions may be of vital importance.

To return to what the manual *does* contain: PART I—Trades, begins with the conventions used in mechanical drawings, the particulars given being excellent, so far as they go—which is *one* page, obviously inadequate to teach a great deal about drawing. The production of castings is then considered with the effects of crystallization and contraction, and giving as three essential rules of design that corners should be rounded, sections

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kept constant, and allowance made for free contraction. Patternmakers are required to possess skill at working in wood and a knowledge of machine drawing, foundry, and machine shop; their materials and tools are mentioned, with the allowances necessary for contraction of various metals on cooling and for machining; their close association with the moulding shop being emphasized. The work of the moulders is treated at somewhat greater length, and hints furnished for the inspection of castings. Under iron founding, the cupola and its working, the mixing of metal, the pouring of molten iron, and fettling, appear. Brass moulding and founding require slight modifications of treatment and are dismissed in a few lines. The operations and plant for smithing and forging are next taken, and then boilermakers' work, with the shop equipment, repairing of tubes, shells, fireboxes, and tube-plates. Heat treatment of iron and steel receives fuller attention and includes hardening, annealing tempering, and casehardening, following which are chapters on oxy-acetylene and electric welding, and the work of the fitting shop in reducing rough castings and forgings to the precise dimensions desired.

Naturally the operations of the machine shop are the subjects of many concise practical remarks on drilling, reaming, turning, cutting speeds of lathes, planers and milling machines, and details of grinding machinery of various types, with warnings of faults likely to be encountered. Quite a considerable amount of data on saws and other woodworking machinery is quoted, with a reminder that serious accidents are particularly liable to occur with this type of plant. Part I of the volume then concludes with some useful appendices showing tables of standard screw threads, wire gauges, and tools required by patternmakers, moulders, smiths, boilermakers, and fitters.

PART II—Heat Engines, discusses internal-combustion and steam plants, the principles on which they work, how to work them, and how to install, inspect, maintain, and test. Taking the internal-combustion engine first, the Otto cycle and the elementary theory of the subject generally are briefly explained, passing on to ignition, speed regulation, lubrication, and instructions of a general nature on the running and care of oil engines, and mechanical starting, giving a table of running faults met with and how they are remedied. A separate chapter is devoted to engines running on heavy oils, *e.g.*, Diesel and semi-Diesel, and their governing, starting, stopping, etc., with a table showing the procedure for maintenance and cleaning operations spread over a period of four weeks. After a brief consideration of the principles and working of gas producers, carburettors for petrol engines receive more congenial treatment, the principles of carburation being set forth with descriptions of such types of carburettors as the White and Poppe, Zenith, Claudel-Hobson, and Holley. The chapter on ignition describes various types of magnetos and has a table of faults, their tracing and remedies, which should be studied together with a table of petrol engine troubles in general, *e.g.*, failing to start, engine stopping, running jerkily, knocking, engine overheating. The information on petrol engines concludes with a helpful list of points to be specially attended to under the carburettor system, ignition, water circulation, cylinders and pistons, valves, crankcase, and carbon deposits.

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Steam engine and boiler principles are next outlined, with the briefest descriptions of common types and their care, working and management, fittings and auxiliaries, the use of oil fuel, natural and artificial draught, valves, and condensers. The lay-out and installation of steam plant include details of pipe-lines carrying steam, materials suitable for the pipes and joints, steam traps (illustrating Sirius and Geipel traps), and lead on to engine testing, which covers the use of indicators, determining the calorific value of fuel, measurement of water evaporated, etc. Finally Part II closes with notes on engine foundations and on the selection of prime movers for the use of engineer services in the field, to assist in which a folding table of the comparative virtues of petrol, oil, heavy oil, steam, and gas engines is inserted.

Part III—"Application" commences with a statement of methods of power transmission, proceeding to give attention to line shafting and its strength and qualities, muff and Universal couplings, plain bearings: their design, fitting, pressures, friction and lubrication; ball, roller, barrel, and thrust bearings; positive, friction, magnetic, and hydraulic clutches and the precautions needed in fitting them; the power and arrangement of belt, rope, and chain drives, and toothed gearing. Indirect transmission systems by electric, pneumatic, and hydraulic means are also noted and their efficiency and applications stated.

A chapter is devoted to the principles and methods of lubrication, viscosity and qualities of oils, with a list of service lubricants which gives their composition, flash points, and viscosities; and another to air compressors: their principles, care, working, and the use of pneumatic tools.

The manual concludes with an outline of factory organization methods for army workshops, with some notes on cost accounts and on repair shops, with examples of forms.

Following a very useful index are 94 pages of illustrations with an immense number of figures which, taken in conjunction with the descriptions in the text, should be of great value.

On the whole, the work is eminently suitable for the purpose for which it has been designed, and no better praise than this is needed. Although it may not cover the vast field of mechanical engineering as practised in our commercial workshops it is really surprising the amount of useful ground treated for the military mechanical engineer, whilst many a member of the profession engaged in civil employment would find that the purchase of the book yielded him the best investment in literature for 3/6 that he had ever had.

MAGNUS MOWAT, *Brig.-General, Reserve of Officers.*
M.Inst.C.E., M.I.Mech.E., M.I.E.S.
Secretary, Institution of Mechanical Engineers.

TEXT BOOK OF TOPOGRAPHICAL SURVEYING.
3rd Edition, 1925.

By Colonels Sir Charles Close, K.B.E., C.B., C.M.G., F.R.S., and H. St. J. L. Winterbottom, C.M.G., D.S.O. (H.M.S.O.). Price 15s.

This text book has now firmly established itself as the best book in the English language on Topographical Surveying, and one which no surveyor should be without.

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The issue of a new edition, the previous one having been issued in 1913, is welcome and more than due, as the Great War has stressed the imperative necessity of maps, and has given rise to developments in various directions.

The principal changes may be briefly noted here.

The improvements in wireless telegraphy have resulted in seven pages being allotted to a subject which in 1913 was dismissed in five lines; the usefulness of this method of determining "relative" longitudes has enabled the authors to dispense with all accounts of absolute methods, for which relief surveyors may well be grateful, accurate results having always been highly problematical.

The increased use of rectangular grids has rendered it necessary to devote increased attention to the various orthomorphic projections. An account is included of the methods of fixing graphically the position of resected as well as intersected points.

The use of the Survey of India forms for latitude, longitude and reverse azimuths has been abandoned with "some reluctance" by the authors, as it is an obvious pity that different forms should be used by officers trained in England and India.

The subject of Airphoto Surveys is now included for the first time; first brought into prominence by its utility in surveying areas in enemy occupation, this method of survey has now become firmly established for all surveys of areas which are unsuitable for planetabling, such as, to take one instance, swampy, low-lying country intersected by creeks; also for city surveys and generally for rapid work, with a suitable ground control, its accuracy is marvellous. Developments in this line have been so rapid during the last year or two that the four pages allotted (against nil in 1913), will probably become forty in the next edition; at present they merely touch on the fringe of the subject. By closer printing the number of pages has been reduced, the book is excellently arranged, clear and well got up, and all that a text book should be. The authors, themselves both distinguished surveyors, are to be warmly congratulated on supplying a book, which is invaluable not only to the beginner but to the expert surveyor.

C. H. D. RYDER.

PORT ADMINISTRATION AND OPERATION.

By BRYSSON CUNNINGHAM, D.SC., BE., M.INST.C.E., F.R.S.E. (Chapman and Hall). Price 13/6.

The author of this volume states that it is impossible to lay down any ideal system of Port Administration, and therefore describes the functions and government of the leading ports of Great Britain and her Dependencies, of the chief maritime nations in Europe, and of the United States.

These ports are simply taken as examples, which shew that in general each port has evolved its own system of government along lines which are most congenial to its nationality, traditions and bent.

The working of each depends on the class to which the port belongs. Ports are classified in regard to situation—sea ports, river ports, etc. As regards trade; coaling ports, ore ports. As regards function, ports of call, transit ports, ports of destination or entrepôt ports, etc. As regards auxiliary services—barge ports, rail ports, etc.

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Systems of port government are also many and varied, but are dealt with under the following heads :—

State Control. This is found satisfactory in the Dominion of South Africa, and undoubtedly has many advantages, but does not commend itself to Great Britain.

Partial State Control of ports is found in numerous countries, at Havre, for example, where the State is responsible for the labour and sea defence work, the docks, dry docks, etc., while the local Chamber of Commerce owns all the sheds, warehouses etc.

This system, in a more modified form, finds expression in the United States.

District or State Control is well exemplified at Boston and San Francisco.

London is an example of Autonomous control which takes the form of a Port Authority with statutory powers. Liverpool and Glasgow are other examples.

Other forms of control are Private, Railway, Municipal etc.

Various organisation diagrams typical of the different types of port control are given.

The chapter on Port Administration deals with a multiplicity of duties and responsibilities of those controlling a port, and how the various financial and engineering problems are dealt with by those in charge.

Rates, dues, charges, warehouse rents and receipts are explained and exemplified. Appendix V is interesting to the layman. It shews, in tabular form, the cost of goods discharged at British ports under various sub-heads, such as Pilotage, Towage, Dock dues, Harbour dues, Local Light dues, Trinity House Light dues, Discharging costs, Tallying, other charges.

A chapter is devoted to Port Labour—one of the difficult and perplexing problems connected with port administration—and others to Port Jurisdiction, Port Belt Lines and Port Bye-Laws.

The volume is full of interesting facts, and though many of these are of greater interest to the specialist in Port Administration than to the general engineer, the latter cannot fail to pick up ideas from the study of the methods employed in the running of such large undertakings as the modern sea-port.

——— G.C.G.

BUILDERS' ESTIMATES AND PRICING DATA.

By H. A. MACKMIN, F.S.I., M.R.SAN.I. (Chapman and Hall). Price 9s. 6d.

This work contains a host of valuable information based on current rates of both materials and labour, and useful tables are included to adjust prices where they vary from the ones given. Constants of labour are given covering a very wide field, and seem on the whole fairly representative of prevailing conditions. A reference is made to the "Constants of Labour" contained in "Hurst's Architectural Surveyors Handbook," with the opinion that they are still the most consistent data of their kind —bearing in mind that allowances must be made for various factors likely to affect them, viz.:—shorter working days, no breakfast interval, workmen's travelling difficulties, etc. Reference is also made to the

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"Constants of Labour" contained in "Works Manual (War)," published by H.M.S.O.

Many useful items, some quite new, together with their labour constants, are included, notable examples being:—Pulling down, preparing for re-use and carting away debris, etc., resulting from demolitions and alterations; jointing of almost all kinds of piping, together with jointing material required; reinforced concrete, with shuttering in some detail; plastering in Sirapite, Keens, Parian, Roman and Portland cements, also White Portland Cement or "Atlas White"; hot water, gas, and other pipe work and fitting.

Attention is drawn to the favourable comparison in cost of copper tubing with lead pipe and galvanized iron barrel, especially in H.W. work, where durability, resistance to pressures, and high conductivity are essentials, also for cold water services in soft water districts and exposed situations.

The chapter on Painting, Paperhanging and Glazing is fairly comprehensive, the comparison between lead and zinc paints being especially interesting and instructive.

Some very bold remarks are made concerning "priced schedules" for jobbing work, one being "The builders are put to the expense of measurement, which . . . in some instances amounts to more than the total cost of the item measured."

A reference to approximate estimates based on the "Cube Method" of pricing is also interesting, and a table is given showing how greatly prices vary for the same class of building. Prices for small houses vary as much as from 10d. to 2s. per F.C., indicating how dangerous they can be in the hands of the inexperienced estimator.

The old measure of "bushel" frequently appears in the book, which could with advantage have been replaced by weight or by a cubic measurement, which is much more satisfactory as a rule. There seems to be an error in the cartage table on p. 28. The last four items of this table should apparently equal so many "bushels" and not "lbs."

This work should prove of great assistance to D.O's, M.F.W's and others engaged in estimating, analysing and pricing building work, especially in the case of directly employed labour.

A.M.

THE PRINCE OF POETS.

By BRIGADIER-GENERAL S. A. E. HICKSON, C.B., D.S.O., (R.E. ret.). (London: Gay & Hancock, Ltd., 1926). Price 7/6d.

THOSE R.E. Officers who had the privilege of reading the discriminating articles on the Roman Territorials, contributed to the *R.E. Journal* of some 23 years ago by the author of the *magnum opus* now published, will have a rare treat in investigating a complex subject with an open mind and observing how, in the past, the deductive methods of reasoning pursued by the author on the Territorial system of some 2,000 years back, have been strangely verified by the experience gained before, during and after the Great War of 1914-1918.

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The " Prince of Poets," or " What's in a Name ?" coming out as it does on the tercentenary date of the death of Francis Bacon, Lord Verulam, is singularly opportune as a mine of wealth and reference book for those Baconian-Shakespearians who wish, if possible, to weigh up the evidence, genealogical, documentary and hereditary, circumstantial mostly, and to reconcile the various opinions as to the duplex achievements and character of the infant prodigy and divine philosopher, Bacon-Shakespeare.

The modern Eugenist and the Facial Artist will be much interested by a perusal of this unbiassed " Prince of Poets " researchful work, whilst the ordinary person in the street will only marvel at the mass and volume of work accomplished by one or even two individuals in the difficult transition period between medievalism and the new learning.

If all the work involved is due to one man, say Bacon, how could a man, immersed in public affairs as Lord Chancellor, possess the time to study the work of the ancients alike in natural science and philosophy and frame a new system of scientific investigation ? Even with the modern aids afforded by the dictaphone, simplified spelling, and broadcasting, the average reader, in mere respect for a great man's memory will deem it kinder not to stretch the marvellous to the ludicrously impossible.

O. E. RUCK, *Colonel (retd.)*
Member of the Society of Genealogists.

London, W.C.1.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

No. 52 (*October*, 1925).—In *Armée de Couverture*, General Camon discusses the action of a covering force to a national army, and points out that its mission is twofold, viz.:—

1. To cover the initial mobilisation.
2. To facilitate the eventual offensive.

The use of a natural obstacle as a base of operations is insisted on, and Napoleon's conception of the offensive value of artificial obstacles (*e.g.*, fortifications) is clearly brought out. The network of railways to be found on the frontiers of modern European countries has had a great effect on the action of a covering force in modern war. The importance of seizing the enemy's frontier railway system to as great a depth as possible, thereby facilitating one's own offensive or forestalling offensive action by the enemy, is clearly shown.

Commandant L'Archer begins an important article entitled *La Campagne du Général de Falkenhayn en Palestine* (1917-1918). The description of these operations is compiled from Turkish sources, comment being made on the remarkable lack of German literature on the subject of the activities of the " Yilderim " group of armies. The article deals mainly with the difficulties and mistakes of the German Higher Command, in their efforts to impose their authority on the Turkish military system, and the various conflicting interests on the Turkish side appear clearly and make very interesting reading. The narrative closes with the eve of the British attack at Beersheba on October 31st, 1917.

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La Bataille de Courcelles-Méry is completed in this number. Considerable attention is given to the habitual (and admittedly sound) tactics of envelopment and infiltration practised by the Germans in their offensive of 1918. The article deals mainly with the successful defence of Méry on June 10th and the partially successful counter-attack of June 11th, carried out by the only four remaining fresh divisions available at the time. It is easy to see from a study of this operation how essential it is for troops on the defensive to be animated with an offensive spirit, and it is from this theme that Colonel de Ripert d'Alauzier draws most of his conclusions.

Capitaine Damidaux, in his *L'Officier d'État-Major*, displays an intimate knowledge of the qualities required by a Staff Officer. These are grouped under the headings of moral, intellectual and physical qualities, and the somewhat formidable array which are discussed show clearly the necessity for intensive training for the Staff Officer, a necessity which was perhaps not generally realised at the end of the Great War.

Poudres et Explosifs (1914-1918) is concluded in this number. Commandant Duchemin discusses chiefly the interesting question of the German efforts to obtain the necessary ingredients for high explosives once the pressure of the British blockade became felt. The article concludes with suggestions for the future in order that France and her Allies shall not again find themselves unprepared for the enormous demands in "matériel" of modern war.

No. 53 (*November*, 1925).—The object of Lieutenant-Colonel Lucas' article, *Des Méthodes de Commandement*, is to summarise the doctrine laid down in various parts of the French Regulations as far as the general duties of a Commander and his Staff are concerned. The conclusions arrived at are familiar to any officer with experience of command or staff work, and coincide almost invariably with the corresponding doctrine in the British Army. The responsibility of a Commander to make decisions and that of his staff to give effect to those decisions is clearly laid down. The most interesting part of the article consists of a comparison of the theoretical and practical attributes of the staff of a higher formation, in which the writer points out the necessity for a senior staff officer to be prepared to give advice on occasions instead of acting invariably as an automatic machine for giving effect to the Commander's decisions.

La Campagne du Général de Falkenhayn en Palestine is completed in this number, the period comprising the Battle of Beersheba of October 31st, 1917, to Falkenhayn's departure on March 2nd, 1918, General Liman von Sanders having superseded him. The ill-feeling between Falkenhayn and the Turkish Generals shows itself throughout these operations, and the failure of the aggressive measures advocated by the German Commander resulted in the supersession of nearly all the German officers at "Yilderim" headquarters, and the removal of Falkenhayn himself.

Capitaine Welschinger, in *Deux Idoles du Peuple Allemand*, compares the characters and careers of two famous German soldiers, Blücher and Hindenburg. Both were called to the supreme direction of their country's army at an advanced age, but Hindenburg never tasted the fruits of victory like Blücher after Waterloo. The writer attributes the German

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failure of 1918 to the lack of the faith in the justice of their cause, which was exemplified by Blücher and Gneisenau throughout the Prussian revival of a hundred years before.

Un acte de la Course à la Mer (4-9 *Octobre*, 1914), by Commandant de St. Denis, is a detailed description of the operations of the 13th Division of the 21st Corps during the race to the sea of 1914. The objective of the division was to ensure the occupation of Lille ; at the end of the period it found itself in a defensive position west of La Bassée. These somewhat complicated operations are clearly described and illustrated by three sketch maps.

Colonel Meynier begins a very interesting article, entitled *A propos des raids transsahariens*, in this number. After describing briefly the various efforts to cross the Sahara made between 1916 and 1925 both by motor car and aeroplane, the writer reaches the conclusion that both these machines must now be considered as practical methods of transport in the Sahara. He then points out the need for their employment to convert an impoverished and rebellious area into a prosperous part of the French Colonial Empire. The remainder of the article is devoted to an interesting description of the use of modern weapons (particularly armoured cars and aircraft) in the British desert campaigns against the Senussi (1915-17) and in Dar-Fur (Sudan), in 1916.

Le Logement des Gens de Guerre sous l'Ancien Régime, by Lieutenant Navereau, traces the methods of billeting and accommodation of troops in barracks prior to the French Revolution, and points out the difficulties experienced during the Great War under the existing law governing the billeting of troops.

No. 54 (*December*, 1925).—It goes without saying that Lieutenant-Colonel Grasset's article, *Verdun—Le premier choc à la 72e division*, is both interesting and instructive. In this number the writer deals with the preparatory arrangements on both sides, and the dispositions are given in great detail and are well illustrated by sketch maps. Special attention is paid to the dispositions of the 72nd division in the sector immediately east of the Meuse.

Colonel Meynier's interesting article, *A propos des raids transsahariens*, is completed in this number. A further example of the use of modern weapons in uncivilised countries is given, viz.:—the British campaign in Somaliland in 1920. Aircraft played a very prominent part in these operations, which were not, however, entirely successful, possibly owing to the effect of purely aerial action having been over-estimated. Colonel Meynier concludes his article with a discussion of the capabilities and limitations of the old and new weapons and methods of transport, *i.e.*, infantry, cavalry and camel corps as opposed to armoured cars, mechanical transport, aircraft and railways.

It is claimed that the future of France lies in Africa, and modern methods of communication are essential for this claim to be realised.

The object of Commandant Martin's article, *Les groupes d'Armées Allemands au cours de la Guerre* (1914-1918), is to prove the unsoundness of the original system employed by the German Higher Command, which was to place one Army Commander in command of other armies besides his own. The best known example is that of Von Bülow and Von Klück

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in 1914. Details are given of the various groupings of the German armies throughout the War.

Rôle Historique des Places Françaises, by Capitaine de Gaulle, outlines the history of the fortresses of north-eastern France since the days of Vauban. After the disasters of 1870, General Séré de Rivières prepared an excellent scheme for the re-organisation of the French system of fortresses, but, apart from Toul, Verdun, Epinal and Belfort, and to a certain extent Maubeuge, his recommendations were neglected. It was largely owing to this neglect that the German sweep through Belgium in 1914 met with such success. Captain de Gaulle concludes his article with the remark that "one door has given entrance to all the disasters which have befallen France throughout her history; it is the door through which the lessons of the past have escaped."

Colonel Bailly' *Essai sur l'Emploi Tactique du Génie*, is divided into two parts:—The effect of technical problems on military operations, and the tactical employment of Corps and Divisional engineers. The first part is illustrated by the effect of permanent fortifications on the operations of the Germans in France in 1914; in the second part the doctrine of concentration of engineers, rather than dispersion among the other fighting troops, is in general agreement with the present day doctrine of the British Army.

Les chars au Maroc en 1925, is a report of the activities of the 1st and 2nd Tank Battalions during the operations against Abdel Krim in Morocco in 1925.

Several lessons are drawn from the experiences of the campaign, but it is realised that the special conditions of Morocco called for modifications in the normal organisation of tank units in the Metropolitan Army. One of the main lessons, however, holds good for all forms of warfare, namely, the necessity for compliance with the regulations for the co-operation of infantry and tanks before and during operations. To support the infantry and facilitate their task remains the chief rôle of the tank, under present conditions.

H. A. J. PARSONS.

REVUE DU GENIE MILITAIRE.

(*January*, 1926).—*The Ivory Coast.* An account of the construction of a canal connecting the lagoon, on which stands Grand Lahou, at the mouth of the river Bandama, to Ebrié lagoon, on which is Grand Bassam, the other part of the colony.

The Water Supply of a Camp. A description of the arrangements made to supply a standing camp for 53 officers, 1,760 O.R's. and 370 horses. The authorised scale was 6½ gallons per man and 11 per horse daily. The source of supply could furnish 40,000 gallons in 24 hours, and the distributing system was chosen of such a size as to be able to give 30,000 gallons in 15 hours (from 4 a.m. to 7 p.m.) from a tank holding 3 days' supply.

La Houille Blanche. A précis of the papers read at the third Hydro-Electric Congress held at Grenoble in July, 1925. The Congress was divided into three sections (*a*) administrative, (*b*) financial and economic (*c*) technical, sub-divided into production, distribution and use; The

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paper includes a description of a laboratory near Grenoble devoted to the study of the production of electric power from water.

Foundations in Sandy Soils. The soils in North Africa are greatly affected by extremes of dampness and dryness. In summer they crack and form fissures up to 40 feet deep, thus making ordinary foundations useless.

If it is possible to keep the degree of dampness of the building constant, for example, by a layer of sand under the foundations, no ill-effects will be found. The only alternative is to build on a reinforced concrete raft.

The Carriage Overland of Ships. A list of various occasions on which ships have been transported overland either as complete ships or in parts, from the time of Cleopatra.

Regulations for the Construction and Use of Septic Tanks.

(*February*, 1926.)—*The Supply of Timber in the War.* The demand for wood until the beginning of trench warfare was almost entirely for fuel. But, in spite of the diminution of civil demands, by April, 1915, commercial stocks were getting exhausted and a general control of timber was organised under the *Direction du Génie* at the War Office.

This system soon proved ineffectual owing to the independent action of the *Intendance*, the Railways, Munitions and other departments, and led to the organisation in 1917 of (*a*) the *Comité Général des Bois*, to control the needs of the various services and their relative urgency, and advise as to means of meeting the requirements, and (*b*) the *Inspection Général du Service des Bois*, to ensure the supply for military purposes and to prepare, co-ordinate and supervise the exploitation of the Allies.

The author claims that the overseas forces acquired much useful knowledge from their contact with the traditional methods of French forestry, particularly in connection with the difficult problem of husbanding their resources.

At the time of the Armistice the requirements meant an annual production of about 200 million cubic feet of wood for work and 50 million cubic ft. for burning.

Before the war, in France there were 24 million acres of forests and in Alsace-Lorraine one million. After the war, in the combat area, i.e., that area occupied by the Germans and 12 miles beyond, there were only 700,000 acres of productive forests. In the interior of France the damage to the forests has not been great, and in general, thanks to the organised cutting, the French forests are in good order, despite the drain on them during the war.

Dealing with any future war the conclusion is reached that the annual production will meet the needs of the Army and of civil life, at any rate at the beginning of a war, without calling on the reserve stock of timber in France, estimated at nearly 2,000 million cubic feet, and that all the qualities of wood required will be available, except perhaps those for aeroplanes.

Crossings of the Euphrates at Deir-ez-Zor in 1924. A description of the methods used to strengthen an existing bridge and provide a ferry, run on an overhead wire rope, capable of dealing with 8-ton loads, over the two branches of the Euphrates.

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Calculations for Reinforced Concrete Beams. A description of the method of calculating reinforced concrete beams by means of a slide rule, the invention of M. Rieger, a Czecho-Slovak engineer and teacher. After a description of the rule and the various scales, a number of examples of various problems are worked out in detail.

The Crossing of the Danube at Sistovo on 23-11-16, *by the Austrians and Bulgarians.* An examination of this operation, prompted by the article in the *Revue du Génie* of September, 1925, divided into a consideration of (i) the choosing of the point to cross, (ii) the preparations, (iii) the crossing, and (iv) the morals to be drawn.

(i) The choice of a point to cross a wide stream such as the Danube depends on

(*a*) Historical considerations, *i.e.*, where previous armies have crossed. This is liable to give erroneous information, as other conditions vary.

(*b*) Geographical and strategic considerations, such as the nearness of a railway system (this is not of great importance, as the railways cannot be utilised until the attacking troops have pushed the defenders some way from the river), of roads (of primary importance for the collection of material for the crossing), the proximity of the objective (*e.g.*, enemy's capital or industrial centres).

(*c*) Technical conditions, nature of the banks, position of islands, width of the stream. At Sistovo these were not considered of such account as (*a*) and (*b*).

The choice of the exact point or points of crossing, as opposed to the region in which crossing should be carried out, ought to depend on tactical and technical considerations.

The choice of the region is the responsibility of the supreme command; that of the exact spot should be decided in collaboration between the commander of the formation to effect the crossing and the engineers.

(ii) Choice of the exact sites from which to start. The choice of the sites for collecting materials for the crossing depends on the possibility of bringing up material by road, unloading it and collecting boats, all out of sight of the enemy.

At Sistovo no choice was possible; three spots were forced on the attackers as the only possible ones. Most elaborate precautions were taken to prevent the enemy from discovering the preparations, by camouflage, by elimination of noise in working and by working at night. It is pointed out that these precautions were not specially thought out for this operation; they were laid down in Austrian and German Regulations.

(iii) *The Materials.*

German one-piece boats were used, as well as the excellent Austrian two-piece boats, which were divisible into the " body " (length 11 ft. 4 in.) and the " beak " (length 13 ft. 6 in.), each weighing approximately 8 cwts. The German boats were not as stable as the Austrian on the Danube with its high waves.

For the main crossing at Sistovo and the subsidiary one upstream at Bélène there were available in all 108 boats to carry 3 divisions, a much smaller figure than that used by the Germans in their crossings.

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(iv) *The Crossing.*

At Bélène three boats went astray owing to the fog, showing the importance of careful arrangements for directing. At Sistovo a curious arrangement was carried out; the boats left *en échelon*, were dressed after they started and went by compass. It worked very well. The motor boats were not a success; those with oars were more reliable.

To sum up, the attack succeeded for four reasons: careful preparations, complete surprise, fog, a very feeble resistance.

Two days after the crossing, a "Herbert" Bridge, capable of carrying 40 ton loads, was erected, 1,000 yards long, in 23 hours, a remarkable feat.

What lessons can be learned?

For the staff—to give the engineers a free hand to make their preparations; for the latter—to prepare a large enough supply of material without being observed; for extremely exact orders to be issued. If all these have been carried out the programme should go as follows:—Infantry and machine guns go across in light armed boats, followed on rafts by more infantry and some artillery. Then come the rest of the troops on ferries and steam boats; next the building of a bridge, capable of carrying heavy loads.

Points to be noted are the necessity (i) for a larger number of small boats for the first crossing, (ii) for empty boats to be brought back quickly, (iii) for the piloting of the boats to be perfect, even in fog, (iv) for the presence of a large reserve of material, (v) for the flanks of the crossing to be covered by fast armed boats, (vi) for echelons, other than the first, to make use of motor power and to go in large boats, and (vii) for having ready material to make a bridge strong enough to carry, without strengthening, the heaviest loads.

The Work of the Institute of Military Science at Warsaw from 1918-24. The objects of the Institute are to increase the efficiency of the Army and to form bonds between the nation and the army—a difficult task, since Poland had not possessed since 1831 an army of her own or any military literature.

Up till 1922, that is, during the war against the Bolshevists and the subsequent demobilisation, the Institute was perforce limited to the publication of regulations and manuals, co-ordinating civilian science with that of the Army and starting military records and a library.

Owing to the varied nature of the armaments in use, a large number of technical works dealing with them had to be produced. In historical work the only attainments were various studies dealing with the past military history of Poland.

In 1920 a commission was set up to standardise military terms used in official documents. In 1921-22 the influence of the French Military Mission was felt in the increase in scientific studies and translations of foreign books. In 1923 abnormal conditions were over, and the Institute began a methodic course for helping military students by putting before them histories of the Great War and previous Polish Wars. In 1924 the Institute started "Przeglad Wojskowy" to keep Polish Officers in touch with foreign scientific work.

The review, "Bellona," was founded in 1916, and was content at first to cultivate Polish military traditions; after the creation of an army, *Bellona* had to deal with all arms, instruction taking the premier place.

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Since then various journals have been started and *Bellona* has been able to deal with more general questions and is modelled on the *Revue Militaire Française.*

March, 1926.—*The Employment of Engineer Troops in the Operations of the IVth Army between 26th September and 11th November*, 1918. The Army Commander laid down that the principal task of the engineers was to keep up the communications, and that the complete success of the operations would depend to a large extent on the speed, governed by the conditions of the roads, at which guns and stores could be brought forward. 13,000 *troops of various descriptions were put at the disposal of the Chief Engineer.*

The article explains how the personnel were employed, how the necessary stores were obtained (almost entirely from the army area) and gives some summary of the results achieved.

Building a Pile Bridge.—A description of the construction of a 200-ft. pile bridge and approaches by the 2nd Engineer Regiment, as part of their technical training in the Department of Herault.

Passage of the Sambre à L'Oise Canal, 4th November, 1918.—The assault bridging methods adopted in the crossing of this canal under the close fire of the enemy, at Etreux.

Several types of bridge were used and are illustrated: (*a*) a duckboard 20-ft. long, 1 ft. 10 in. wide at the ends and wider in the middle; this bridge was found to have considerable lateral vibrations when crossed by men at the double. Such bridges were used for crossing at locks and weirs; (*b*) to cross the canal 60-ft. wide, a bridge with three floating piers either with barrel or cork rafts, the buoyancy of each pier being 420 lbs. Considerable vertical articulation was necessary to allow the bridges to be launched over the tow path; (*c*) smaller two-span floating bridges to cross a small stream 20-25 ft. wide; (*d*) trestle bridges to be built as the attack progressed; (*e*) timber bridges to carry artillery and 3 ton axle loads.

Road Building.—A portion 2½ km. long of a "chemin bicinal" in Haute Savoie was built as a technical exercise by engineer troops with some slight infantry assistance. Details of the road formation, culverts, embankments, etc., are given, together with some interesting notes on the behaviour of the various machines, stone-crushers, compressors, etc., which were used.

A large proportion of the road was on the side of the mountains, and a considerable amount of drilling and blasting was necessary.

Water Supply for Military Establishments.—A *resumé* of a Circular issued by the Minister of Hygiene in July, 1924, relating to the methods to be employed in ensuring the purity of water supplied to barracks, etc., to the keeping existing supplies pure, and for ensuring any future projects should be properly examined before approval.

BULLETIN BELGE DES SCIENCES MILITAIRE.

(1925—Tome II. Nos. 3 to 6 inclusive).

(*Continued*).

An account is given in Nos. 4 and 5 of the incidents of October 8th in connection with the withdrawal of the Belgian Field Army to the new

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base at Ostend. The main body of this Army was now falling back to the line of the Ghent-Terneuzen Canal. The situation was reviewed at Belgian G.Q.G. on the morning of October 8th ; the latest information to hand led the Belgian High Command to the conclusion that the British 7th Division would probably be able, after all, to reinforce the Belgian Field Army in time to check the further advance of the Germans. In consequence, orders were at once issued with a view to a stand being made on the line of the Durme ; it was still hoped that touch would not be lost with Antwerp altogether.

In the meantime, von Werder, who had been placed in command of the Left Wing of the Germans besieging Antwerp, had received orders to transfer as large a force as possible to the north bank of the Scheldt and to push forward without delay to Lokeren ; the intention of the German High Command was to complete the investment of Antwerp forthwith, with a view to cutting off the line of retreat to the westward of the fortress. The Germans imagined that they had succeeded in bottling up the whole of the Belgian forces and the R.N.D. in the great citadel and were quite unaware that the troops with which they had been in collision at Termonde and Schoonaerde were really parts of the Belgian Field Army ; they fancied that they had been dealing with odd detachments guarding the L. of C.

On the morning of October 8th, units of the Belgian 3rd Division were in the neighbourhood of Lokeren ; accordingly, shortly after von Werder's troops were set in motion on that day, a collision took place between the opposing forces. Von Werder does not seem even then to have realised that it was the Belgian Field Army that he had run up against. The " fog of war " in this region seems to have been as dense as a "London particular."

The " Race to the Sea " was now in progress, and the movements of French 2nd and 10th Armies and the B.E.F. are briefly touched upon in No. 4. Measures had been taken by the British Government for reinforcing the R.N.D. in Antwerp, and a detachment of R.M. Artillery with 16 field guns had been landed for this purpose at Dunkirk. However, the German Right Wing had advanced very rapidly towards the coast and was at this time threatening Lille and Ypres ; the British plans were, in consequence, modified, and the R.M. Artillery did not continue its journey. Sir H. Rawlinson, who was responsible for the British troops sent to the aid of the Belgians, had his Headquarters at Bruges. At 7.45 on October 8th, General Paris telephoned to him and stated that the R.N.D., together with the Belgian 2nd Division and some fortress units, had taken up a position on the Second Line of Defence, which was insufficiently prepared and untenable, under a heavy bombardment, by worn-out and inexperienced troops.

There were many cross-currents at this time ; needless to say, they created dangerous eddies and the situation was much aggravated by a very " divided " command—with strange " links " in it (see No. 5). The Belgian and British views as to the employment of the British reinforcements which had been landed at Ostend and Zeebrugge did not coincide. However, King Albert continued strongly to represent the views of the Belgian High Command, namely, that the disposi-

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tions of the British troops in Belgium should be such as to ensure the safety of the line of retreat from Antwerp to the coast. Eventually, the King's representations bore fruit ; at 17.45 on October 8th, Rawlinson received a message from Lord Kitchener directing him to make dispositions to assist the retirement of the Belgo-British troops first on Ghent and then on Ostend.

In the meantime, the defence put up by the Belgian 3rd Division at Lokeren was weakening, and as other Belgian troops were now in jeopardy, the Belgian High Command decided to abandon the intention to make a stand on the line of the Durme and a retirement of the Field Army to the left bank of the Ghent-Terneuzen Canal was ordered. Measures were at the same time adopted to cover the withdrawal of the Belgian 2nd Division and the R.N.D. from the entrenched camp.

The last phase of the resistance of the Belgo-British troops on the Second Line of Defence is dealt with in No. 6. Generals Dossin and Paris, having jointly considered the situation, had come to the conclusion that, in view of the violence of the German bombardment, it would not be possible for the force to hold out much longer. A report to this effect was made to General Deguise, but he would not accept the views of the two subordinate generals ; he reiterated his demand for a "résistance à outrance."

Prior to his departure from Antwerp, the First Lord of the Admiralty had issued instructions directly to General Paris to the effect that the latter should endeavour to put up a stubborn defence, but he was, nevertheless, to consider himself free, apparently at his own discretion, to cut his way to the left bank of the Scheldt in order to rejoin the force under Rawlinson, or any other British troops. Accordingly, when General Paris telephoned to Rawlinson, as stated earlier, he informed the latter that it was probable that he would be forced to retire at the end of the day ; he did not report this conversation to the Belgian authorities, nor did he communicate to them his intention to withdraw the R.N.D. from Antwerp.

The Germans selected the section of the front comprising Forts Nos. 3, 4 and 5 for the break-through, and, having brought their heavy artillery into position, began to bombard these works. A brief reference is made to this artillery action (No. 6).

General Dossin continued to exhibit considerable anxiety in relation to the task set him and sought further instructions from General Deguise. Accordingly, an order—the text of which is set out in the original article—was issued from Fortress Headquarters, wherein were set out the circumstances in which the troops on the Second Line of Defence might withdraw from their positions, and the destinations they should make for. In his turn, General Dossin, at 13.45 on October 8th, issued orders to the Commanders of the Belgian troops under him and also to General Paris indicating the routes by which the several formations and units concerned should retire when it became necessary to abandon their positions. Within an hour of the drafting of General Dossin's order some of the Belgian troops on the Second Line of Defence began to fall back.

German Tactics. The original article, which appears in No. 3, is a compilation based on the regulations for the German Army and certain

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other works, a list of which is given. The following matters are dealt with in the original article: the details of the new organisation of the German infantry, its training, and the principles for its employment in the battle; the new organisation of the German artillery and the part it is expected to play in the battle; the new organisation of the German cavalry and its rôle in war; the employment of cyclists and armoured-cars is also touched upon; the general principles relating to the employment of field defences are stated; brief references are made to aerial attack and anti-aircraft defence, gas-warfare and tanks. Captain Weber, the author of the article, points out that no attempt is made in the German regulations to conceal the fact that questions of organisation and preparations for war have been approached in the *Reich* from the point of view of the effectives, armament and equipment of a great military Power, and not alone from that of the army of 100,000 men, which is allowed to Germany under the terms of the Treaty of Versailles. Those who wish to keep themselves abreast of what is taking place in the military sphere in foreign lands—there must be many such in the Corps—will find Captain Weber's article exceedingly helpful to them; it gives, so to speak, a bird's-eye view of the new German Army as it has been rebuilt on the lessons of the Great War, as interpreted by its brainy ones.

Infantry Bridge. The original article is contributed by Major Mascart and appears in No. 4. Major Mascart is of opinion that sufficient attention has not been given to the provision in Engineer Parks of material for light infantry bridges for crossing waterways on floating piers. The problem is discussed and particulars, with illustrations, are given of an equipment designed by Major Mascart for a bridge to take infantry in single file. This equipment consists of longitudinal and transverse girders of duralumin and floating supports, similar in appearance to the Blanchard cylinders of long ago—but smaller in size. It is suggested that rubber-covered linen, and not metal, should be used for the floating supports, which might be filled either with straw or a number of air-filled rubber bladders, as used inside the leather jackets of footballs.

W.A.J.O'M.

THE MILITARY ENGINEER.

(*Jan.-Feb.*, 1926).—*Theory and Practice with 2nd Engineers.* An account of Engineer work in the Great War, written to illustrate the importance of Field Engineers being always prepared for emergencies, and shows how at Chateau Thierry—Soissons and on the Meuse—Argonne, engineering problems seldom worked out as planned, owing to sudden changes in the military situation.

The Army "Air Experience" Course. A description of a short course of flying which officers of all arms should take.

The aim of the course is to enable all officers to appreciate the possibilities of aircraft, to learn what can and cannot be seen from an aeroplane, and to direct an aeroplane over a given route on a map, obtaining the fullest details of the terrain flown over.

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Tactical Use of Combat Engineers. Previous articles on the same subject have all been written with a view to arrive at the most satisfactory organisation of Divisional Engineers to enable them to take part in battle as infantry. The writer in this article suggests that engineers should never be used as infantry except in the very last resource, and that by functioning as engineers, either in attack, defence or retreat, they can be of much greater assistance to the infantry than by being thrown into the line to use their rifles.

The 7th Engineers Bridge the Meuse. An interesting and highly instructive article on the Bridging operations during the Meuse-Argonne offensive in November, 1918. The lessons to be learnt from these operations are :—

1. Value of information obtained from reconnaissance and from maps, aeroplane photographs and civilians.
2. Importance of deceiving the enemy of the actual points of crossing by careful preparations at selected points distributed over as large a front as possible.
3. A successful crossing was made at a point which from an engineering point of view presented great difficulties, thus illustrating the factor of surprise.
4. The importance of meteorological conditions. The crossings were assisted by cloudy weather and poor visibility.

The Influence of Bridges on Campaigns. As the campaigns selected are all from ancient history some five hundred years B.C., no useful technical data are obtained, but the article is of interest as it shows the importance of Bridging operations was as great in those days as it is now.

C.G.M.

HEERESTECHNIK.

(*January, February and March* numbers.) Dr. Becker, in his article *On the Measurement of the Velocity of Projectiles by Photographic Means*, describes a number of most ingenious instruments, which he classifies in two main classes : measurement by artificial light, and measurement by daylight. In the latter class the most interesting instrument operates as follows : Two photographs of a projectile are taken on a film which by repeated trial is made to move at such a speed that the two images coincide. On the same film the vibrations of a tuning fork are reproduced photographically, by which means the speed of the film is known exactly, and a simple calculation gives the speed of the projectile.

Major Buhle reviews at length a book by Col. Rimailho, *Artillerie de Campagne.* Col. Rimailho's name is closely connected with the development of the French field artillery, and at the present time he is head of the construction department of the factory of St. Chamond. It is evident that considerable respect is paid in Germany to his opinions.

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Major Justrow carries on the wordy battle between himself and Lt.-Gen. Rohne, on the range, muzzle velocity and weight of projectiles; but this is to be the last of it, as far as this magazine is concerned, for the editor is getting tired of it.

Twenty-five pages are devoted to a review of the German Automobile Exhibition held at Berlin in November, 1925; the article deals entirely with the civil aspects, and is accompanied by numerous photographs and diagrams.

Progress in Civil Concrete Practice, is the title of an article by Lt.-Col. Augustin. He gives figures showing the alteration of the analysis of cement in the last few years, and the improvement in its strength in tension and compression as shown by the regulation tests, and in its speed of setting.

Dr. Hanslian reproduces at length the views of a Russian writer on *Gas Shelters, and the Protection of Buildings, etc., against Gas*. The Russians in general seem to place very great value on gas-warfare, particularly in conjunction with the airarm. The needs of a country, says the author, may be divided into three classes: (1) protection of dug-outs, etc., in the field, by means of a suction pump with replaceable filter, worked by hand; (2) protection for buildings, fortresses, etc., by means of petrol or electric motors, the filter in this case being a fixture; and (3) ventilation schemes for factories, telegraph offices, etc., in which fresh air is drawn from pure upper strata of air, so that no filter is required. Calculations then follow as to the amount of oxygen required, and percentages of carbon di-oxide present in rooms, etc. (*To be continued*).

Dr. Stadie writes in terms of high praisé of the Russian motor reliability tests, which he considers were arranged better and more practically than any others so far held.

An anonymous article *Coal* deals with the mining, sorting, and use of the mineral in industrial furnaces.

Dr. Becker writes *On the Ballistic Density of Air*, a term which he defines as "an assumed value for the density of the air, which, acting uniformly on the projectile during the whole of its flight would have the same effect on the range as the actual density of the air."

T.H.B.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(Numbers *January to April*).

Captain Fritz Heigl contributes an impartial and well-written article, *The First Tank Battle, Cambrai*, which agrees with the best accounts published in England.

Colonel Robert Pohl, who during the whole war held important staff appointments on the Italian front, writes on *The Conduct of the War by the Central Powers against Italy*. After a brief preface on the relations between Germany and Austria with reference to Italy, he reviews in

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turn the chief operations on the Italian front, the lion's share being devoted to the offensive on the Isonzo in October, 1917. The immediate motive of the attack was the realisation that under another Italian attack the Austrian defence would fail, so that Trieste and the sea coast would be lost. Ludendorff wrote: "Under the circumstances the use of German troops in Italy for purely defensive purposes would have been useless to us. The G.H.Q. were forced to see the necessity of an attack . . . In spite of the diverse views as to the value of a partial success, the attack on Italy had to be decided upon in the middle of September, to prevent Austria's collapse." Tempting as were the prospects of an offensive from South Tirol, preparations for it required three months; so that winter's approach left no alternative to an offensive on the Isonzo and a break-through between Flitsch and Tolmein. From Tolmein to the south, where the object of the attack on 24.10.17 was to pin down the enemy, the Austrians were in a minority of 2 to 3, but on the front of the break-through, in a majority of nearly 2 to 1. The attack compelled the Italians to give up in two and a half days all that two and a half years and eleven battles on the Isonzo had won for them, and moreover they had to retire to the Tagliamento, 60 kms. back. The exemplary orders for the 14th Army ran: ". . . . By incessantly pressing forward by day and night to leave the enemy no time to prepare a new strong position." The Italian Court of Enquiry stated: "The uttermost exploitation of the unexpected initial success and the tireless pursuit frustrated every attempt at holding a rearguard position." The bulk of the Italian Third Army was behind the Tagliamento early on the 31st; but the Second Army was in the main captured; of the 180,000 prisoners and 1,500 guns taken up to the 31st, the majority—over 100,000 men and 1,000 guns—were cut off on the 30th and 31st near Codroipo and Latisana.

The results of the offensive are well-known, that seven French and five English divisions were transferred from France to Italy, and that the tension on the Western front was relieved.

Lt.-Col. Kiszling describes *The Recapture of the Heights of Runcul Mare; an Infantry Attack with reversed Front in woody mountainous Country*. The Austrian 71st Division, in following up the Rumanians too boldly, were nearly cut-off; but gambling on their greater experience, the Austrians were able to re-group their units, and to make a counter-attack which extricated them from the danger.

The Influence of the Commander in Battle, is the title of a very interesting contribution by Lt.-Col. Ruggera. Unfortunately, it is quite impossible to make an adequate summary of a rather long article.

Major General Nowakowski writes on methods of projection of maps for military purposes, on the difficulties of co-ordinating consecutive map-sheets, and the system of rectangular co-ordinates. The article is not intended for those who have made any study of the subject.

Major Stuckheil writes, *The Second Investment of Przemysl*. Quoting from official documents, published in 1915, he outlines some of the financial and other difficulties, experienced before the war, in maintaining the fortresses of the Austrian Empire in sound military condition, and states that the causes of the fall of Przemysl were primarily insufficient preparations in time of peace. "The greater part of the work" (*i.e.*, of bringing

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up supplies) " remained to be done in the few weeks between the outbreak of war and the first investment of Przemysl." In the general plans for the supply of the troops in the fortress, a definite limit was set to the rationing . . . . a garrison of 85,000 men and 3,700 horses were to be provided for for three months. We must deem this a very modest figure when we remember that, according to pre-war theory, where possible, the resistance of a fortress should not come to an end until the military resources of the land were exhausted and the continuation of the war was useless." Between the two investments of the place, supplies of all sorts were taken from it for the use of the Army in the field. (*To be continued.*)

Col. Feichtmeier writes on *Night Operations*. " From before the War to the very earliest times it is seen that battles were seldom fought at night, in contrast to which war history shows that the night was utilised to cover movements and preparations, and the battles began with the first light of dawn . . . . The object of this study is to investigate, in the light of actual examples occurring during the war, to what extent the views prevailing before the war were justified." " In the late war both movement and action were carried out by night to a greater extent than in previous wars; but the cause of this was not due to a greater partiality for night work; on the contrary, dislike of night work was greater than ever, for the experience of the war was that a night attack seldom led to a lasting success." The author then briefly reviews nine night operations of the last war, choosing fairly representative examples each account includes a summary of the general conditions, objectives and degree of success attained. Summing up his conclusions, he says, with reference to the attack :—" The difficulties of the night attack do not only demand fresh troops of excellent morale, but troops with special training. The strength of the attacking troops should never exceed one division. The objectives must be limited, and the preparations thorough. Surprise is essential, success depends entirely on it; therefore the infantry open the proceedings alone without support of artillery or of other arms." In regard to the defence, the author says :—" Well-organised defensive fire is the critical factor. Of particular value is frontal fire by machine guns; to the direction and co-ordination of the night lines special care must be paid. Efficient listening and observation posts give ample warning of the attack. Immediate counter attack made by the first line reserves and accompanied by heavy bombing and shouting is demoralising, and being over known ground, is the quickest method of stopping the advance. The counter attack must be made with co-operation of artillery, but all events it must be carried out before dawn." Under the title *The Last Book of the Field Marshal*, Lt.-Col. Glaise Horstenau reviews Conrad's memoirs, in particular the last volume, dealing with the period from October to December, 1914. *Tanks in* 1925 is written by Capt. Fritz Heigl. The chief points on which great light is required are the English Vickers and the French " Char Leger," particularly the new model of the latter provided with " rubber chains."

T.H.B.

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MILITAR-WOCHENBLATT.

4th January.—1. *Military political retrospect of* 1925. The army is praised and it is demonstrated that in spite of the Treaty of Versailles it has a *Commander* (though officially he is merely "adviser" to the War Minister), a General Staff, and an increased Police Force. It is asserted that France will not support general disarmament. The writer gloats over French difficulties in Morocco and Syria and predicts trouble for Britain in Iraq, Egypt and India, while admitting that the English are clever in getting round difficulties by temporarily yielding. Peace and order in Italy depend on the person of Mussolini.

2. *Voyage of Zeppelin L.59 to Africa.*—A description of the voyage. When over Khartoum, on its way to succour German troops in East Africa, L.59 was recalled. While dropping bombs on the "fortress of Naples" on the return journey, L.59 was brought down by the gun of a submarine, the crew being burned to death.

11*th January.*—1. *Influence of the Latest Tanks on Operations.* Attention is drawn to the use of mechanical vehicles during both French and British manœuvres. The performances of the British Medium Mark D are described as astonishing.

2. *Reichswehr.* An article dealing with the new defence force. The difficulties of recruiting are described.

18*th January.*—*Problem of the Defence of Poland in a Future War.* Polish military organisation and the training of her youth are examined—both are in contradiction to the pacific utterances of her statesmen.

25*th January.*—1. *War Atrocities.* The necessity to combat the legends of German war atrocities is pointed out.

2. *Why the Minenwerfer is an Infantry and not an Artillery Weapon.* The writer concludes from personal observation and from conversation with officers of the various arms that the infantry must have this weapon directly under its command.

4th February.—*The Disarmament Conference.* The seven main problems, given by the League of Nations for solution by the conference, are discussed. The writer considers that they are framed in such a way as to defeat in advance any attempt to obtain unanimity among the delegates, and this will prevent a successful issue.

11*th February.*—*Aviation and Locarno.* The writer refers to Treaty limitations on German aviation. He points out that all lines from west to east and from north to south must pass over Germany and that if Germany has to continue to forbid flying over her territory by other countries, the world as a whole will suffer. He hopes the Locarno spirit will be applied to find a speedy solution.

25*th February.*—*The Legacy of the War Survey Organisation.* The legacy consists of three main discoveries—the taking of aeroplane photographs—the apparatus for plotting on maps accurately from such photos—the development of military geology in trench warfare.

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4th March.—The Importance of Anti-Aircraft Artillery. The writer refers to an article of *La France Militaire* of 13th January, 1926, calling attention to the neglect in France of the anti-aircraft gun, owing to the efforts to discover a gun of accompaniment. He deplores the fact that Germany shows a similar neglect although she is open to aeroplane bombardment from all sides, and urges the study of anti-aircraft defence with a view to obtaining good organisation and a better gun. If this is not done the moral of the population may give way in the opening stages of a war.

11th March.—1. *English War Preparation in Belgium before the World War.* The writer declares himself to be in possession of a secret War Office publication entitled "Report on Belgium, south of the Line Charleroi-Namur-Liège, and on Brussels, from the point of view of Aviation, 1914." He examines the contents of this pamphlet, which shows that aeroplane military landing places in Belgium had been reconnoitred and concludes that the violation, by Germany, of Belgian neutrality was merely an excuse on the part of England to enter the war, a course which she, in any case, intended to adopt.

2. *Tank Obstacles.* The tank obstacles used by the Germans during the war are described. The anti-tank gun is considered to be the best form of defence.

18th March.—1. *Defence against Tanks with Ordinary Weapons.* The best weapon at present in the possession of the German army is the field gun. Automatic shot guns, on account of spread of pellets, are effective when vizor is open; if further trials fulfil expectations one shot gun per machine-gun and rifle section will be issued.

The 2c.m. machine-gun mounted on a motor bicycle and organised into a mobile section of 20 to 30 bicycles per division would be very effective, in the opinion of the writer.

2. *The Training of Reserves during the War.* An article of historic interest showing how this question was tackled in Germany.

4th April.—1. *The Infantry Gun.* A battery of 6 guns per regiment is recommended, so that a section may be allotted to each battalion, but the road space occupied by the regiment will be greatly increased. The battery commander would act as artillery adviser on the regimental staff. The tactical requirements of such a gun are discussed in some detail.

2. *Age Tables for the Army.* Tables showing the number of men of various ages. The bulk of the army is between 20 and 27 years old.

18th April.—1. *Armament of Future Warfare.* The writer discusses the question of defence against air, tank and gas attack. He considers that no country can defend itself with success against these weapons, owing to the unsatisfactory development of defensive weapons.

2. *Dornier Red Cross Aeroplane.* This machine is fully described. It is stated that it has been used in recent colonial wars (not specified) with success.

J.R.K.

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CORRESPONDENCE.

To The Editor, *The Royal Engineers' Journal.*

SIR,

An interesting article appeared in the March number of the *Journal* about the construction of the bridge over the Tochi at Tal, in Waziristan. The calculations for waterway and depth of foundations in this article call for some comment. They appear to be based on a method laid down in a Circular issued by the Chief Engineer Northern Command in March, 1919, which is briefly as follows :

The velocity of the stream in flood is found by Manning's formula,

$$V = \frac{1.486}{n} \times r^{\frac{2}{3}} \times s^{\frac{1}{2}}$$

in which V = the velocity, n is a constant depending on the nature of the river bed, 'r' is the hydraulic mean gradient, *i.e.*, the sectional area divided by the wetted perimeter, and 's' is the inclination of the water surface; n r and s can be found by actual observations of the river bed when there is no flood.

The 'discharge' is the product of the cross section and the velocity.

To allow for unusual floods, $\frac{1}{3}$ is added to the discharge and the corresponding cross section and hydraulic mean gradient discovered by trial. A new velocity is then calculated.

The 'afflux' caused by the piers of the bridge is found by means of a somewhat complicated formula.

The velocity under the bridge is next found from a formula

$$A_2V_2 = 1.1 \ A_1V_1$$

in which V_2 is the velocity under the bridge, A_2 the reduced area, A_1 the cross section including that due to afflux and V_1 the velocity calculated from the assumed discharge.

(It is not clear why afflux should be taken into account in considering the cross section. Owing to the increased cross section the velocity at the point of afflux must be actually less than V_1).

With the velocity so found, the probable scour is then calculated by using Kennedy's formula $V = md^{.64}$ where d is the depth at which a velocity V causes a condition of neither silting nor scouring, m being a constant depending on the nature of the bed.

If V_1 and V_2 are respectively the velocities under the bridge before and after scour and d_1 and d_2 the corresponding depths, assuming that the discharges remain the same, it can be said that

$$d_2V_2 = d_1V_1, \qquad \text{and} \qquad V_2 = md_2^{.64}$$

$$\therefore \ d_2^{1.64} = \frac{d_1V_1}{m}$$

d_2 is the probable depth of scour and for safety it is recommended that it be increased by 50%.

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In the article referred to, Manning's formula has been wrongly stated as $V = \frac{1.486}{n} \times r \times s^{\frac{1}{2}}$, the index of $\frac{2}{3}$ to r having been omitted. This is a misprint, as the working out is correct for $r^{\frac{2}{3}}$.

In the calculations for afflux the reduction of area has been taken at 10 per cent. whereas it appears from other data to be about 13 per cent.

For calculating the depths of scour the equation at the top of page 5 should read $d_1^{1.64} = \frac{6 \times 21}{2.1}$, making d_1 about 12 feet instead of 19.

A manual has recently been brought out in India dealing with roads, namely *Military Engineer Services Handbook, Vol. III*, in which a more detailed and complete system of calculating waterway and depths of foundations is given.

This system appears in the main to be an elaboration of the Chief Engineer's Circular and the question of scour is more completely dealt with. A different formula, Merrimans', is given for calculating afflux, and in calculating the velocity under the bridge, half the afflux is considered in arriving at the sectional area.

It seems that an inherent fallacy exists at the outset in calculating the velocity and discharge, in that the data for finding the sectional area and wetted perimeter are derived from observations of the bed at 'no flood,' and that no account whatever is taken of the deepening of the river bed by scour in times of flood. In Plate IX of the *M.E.S. Handbook*, a sectional view of a pier is given showing 'original bed' and 'scoured bed,' as if no scour took place in a river bed until an obstruction was built in it. It would appear more logical if in calculating the velocity some allowance was made for the increased section of the river bed by its temporary enlargement through scour, which in the case of a well defined bed would be fairly uniform over its width.

The formula on page 45 of the *M.E.S. Handbook*, $DV_2 = D_1V_3$, corresponding more or less to that quoted from the Circular, seems to be vitiated by the fact that D is the observed depth to the bottom of the scoured bed before obstruction, but V_2 is the velocity calculated from the area in which the depth is that observed at a period of 'no flood.' In other words, D does not correspond to V_2.

The question as to whether it is admissible to restrict the waterway of a river bed is an interesting and debatable one. The *M.E.S. Handbook* lays down that it is generally inadvisable, but it can certainly be done with advantage in the case of small river beds in which the stream in flood spreads unevenly over a wide area.

Seeing that the waterway for both the bridges over the Tochi at Shinkai is about 200 feet wide, it would appear that the bridge at Tal, where the discharge is less than at Shinkai, might well have been made one span shorter without very expensive training works.

I am, Sir, your obedient Servant,

A. H. BELL, *Lt.-Col. R.E.*

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31, Hertford Street,
Cambridge.

To the Editor, *The Royal Engineers' Journal.*

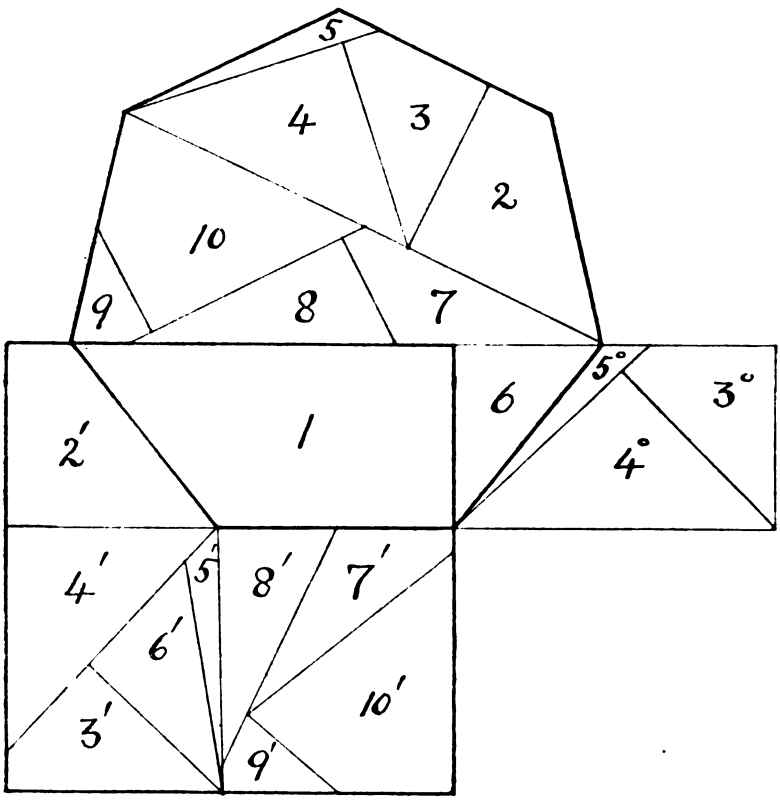
DEAR SIR,

The late Col. Arkwright, R.E., with whom I was in constant correspondence, sent to me, shortly before his death, the enclosed clever dissection of a regular heptagon into a square. He was in the front rank of those who studied the transformation of figures by dissection, and I have thought that you would like to preserve it.

Yours truly,

PERCY A. MACMAHON, *Major.*

Dissection of Heptagon.



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COOPER'S HILL WAR MEMORIAL PRIZE ESSAY.

THE second of the triennial prizes presented to the Corps by the Cooper's Hill Memorial Fund is for competition during the year 1926, and the Council of the Institution of Royal Engineers has chosen the following subject :—

"The effect of mechanicalization of the Army on the organization and employment of Divisional and Corps Engineers in the Field."

Essays must reach the office of the Secretary, Institution of Royal Engineers, not later than the forenoon of the 1st September, 1926. Essays must not be signed, but each must bear a pseudonym and the name of the writer enclosed in a sealed envelope must be attached.

The Cooper's Hill Memorial Prize is a bronze medal, a parchment certificate, and a sum of money, about £20.

(*a*) *Qualifications of the Competitors.*—To be a regular officer of the Royal Engineers under the age of 35 on the 1st January of the year in which the award is made.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize shall be awarded by the Council of the Institution of Royal Engineers in the manner considered best for the encouragement of contributions on professional subjects, by R.E. officers, to the Corps publications. From the beginning of 1920 it was decided that the Prize should be offered to officers on the Active List not above the rank of Substantive Major.

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy ; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside ; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications ; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions :—

(*a*) Descriptions of works actually carried out in peace or war.
(*b*) Inventions.
(*c*) Design (excluding works of defence).
(*d*) Labour organization on work.
(*e*) Scientific investigations generally.
(*f*) Accounts of exploration work and surveys.

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ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

Subject selected :—"Survey on Active Service."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2 :—

(a) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary? What projection would you employ and what steps would be taken to begin Survey operations ?

(b) Do you consider the resources of the Field Survey Company adequate in personnel to undertake the programme you have outlined ? If not, what additional personnel do you consider necessary ? What reply would you make to the offer of the Colonial Survey given in paragraph 7 ? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make ?

2. The Force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of Non-Divisional and L. of C. Units. These include 1 Field Survey Company plus Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foot-hills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and are all unmetalled except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ½-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section armed with revolvers and issued with pantaloons may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the Text Book of Topographical Surveying.

3. The printing machinery includes 1 double demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

Essays must reach the office of the Secretary, Institution of R.E., not later than the 30th November, 1926. Essays must not be signed, but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with a similar pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

1. The prize, which will take the form of a piece of plate, to be chosen by the the recipient, was instituted by Mrs. Garrett in memory of her late husband, Major Arthur ffolliott Garrett, O.B.E., R.E.

2. Qualifications of the recipient : To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1926.

3. The essay must not exceed 6,000 words.

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CONSTABLE

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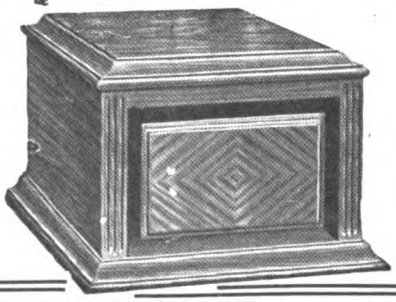

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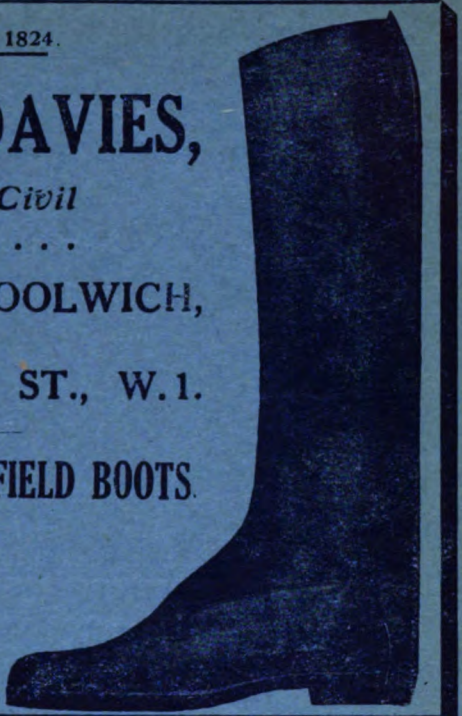

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ROYAL MILITARY COLLEGE OF CANADA.

"TRUTH, DUTY, VALOUR."

By MAJOR GENERAL G. WALKER, C.B., C.M.G., D.S.O., late Royal Engineers.

This is the Jubilee year of the Royal Military College, Kingston, Canada, and it has been suggested to me that, as I have some personal knowledge of the very early days at the College, and as the institution has been intimately connected with the Corps, I might write a few notes of those days. I have accepted the responsibility with some diffidence, as I am not a graduate of the College. Yet, as one who was very closely connected with one of the first R.E. Officers on the College Staff and, as I have I think a legitimate pride in that relationship, seeing how well the foundations of the Institution were laid, I feel I am justified in my temerity.

That the College is and has been a great Imperial asset is I think incontrovertible, when one looks back on the long line of distinguished British Officers it has produced; men who have gallantly upheld the honour of the Empire, of their own Home-Land and of their Alma Mater. It must not be overlooked also, that the fame of this Institution does not rest alone upon the exploits of its graduates who entered the Imperial Army. The history of Canada is full of the names of distinguished Administrators, Engineers, and Soldiers who owe their initiation into life to the old College.

The R.M. College of Canada was opened at Kingston, Ontario, in 1876. The first batch of Cadets numbered 18, who went by the name of the "old 18." Some of them were elderly I imagine, as I remember the Senior Cadet of that term well. His name was Homfray Irving. He was a small man and his mutton-chop whiskers, eyeglass and general appearance of solemnity and sedateness impressed me much, as it possibly did others. I wonder if I malign him, he could only have been about 20, but then I was only 8. At the recent Jubilee celebrations he, with three others of the "old eighteen" unveiled a commemoration tablet.

The Cadets who took Commissions in the British Army from this term, were, as far as I remember—A. B. Perry, R.E. (He broke his leg before joining and that so badly, that he resigned his Commission the following year, though he has lived to be the distinguished Commissioner of the North West Mounted Police, and after distinguished service in the War is now a Major-General.); C. O. Fairbank was the Gunner; Wise went into the 13th Hussars; Frere went into the Infantry. When Perry retired, his vacancy in the

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Corps was given to A. H. Van Straubenzee, now retired as a Colonel. He belonged to the 2nd Batch and had been originally commissioned in the 101st Foot, later the Royal Munster Fusiliers, from which he was transferred to the Royal Engineers, vice Perry. The second batch at the College was headed by H. B. Mackay, who became a Royal Engineer. He was I think the "biggest man" the college possessed in those days, and all who knew him looked upon his early death in Africa as a great loss to the Service and State. W. H. Robinson, who was the next R.E. Graduate, was killed in storming a stockade in West Africa. Lang Hyde, the next, is still with us, but retired.

The above were the first four Sapper Graduates, but they have been followed by many others who have distinguished themselves. To name a few only, Lieutenant-General Sir George Kirkpatrick, now Commanding an Army in India, Major General Sir Philip G. Twining, Colonel Sir Percy Girouard, Major Generals Dudley Ridout, A. C. Joly de Lotbiniere, and Brig. Generals H. C. Nanton, G. S. Cartwright, W. B. Lesslie, and A. E. Panet. Another R.E. Graduate who requires special mention was W. G. Stairs, who was a great African explorer and accompanied H. M. Stanley on his last expedition. He was subsequently given a captaincy in the Welch Regiment and ultimately died in Africa while in command of an Expedition for which his services had been lent to the King of the Belgians.

Although this article deals with the College chiefly from the R.E. point of view it is worthy of note that the College has produced men like Lieut.-General Sir W. Heneker, recently commanding the 3rd Division; Major General Sir G. Cory, recently Deputy Chief of the General Staff in India, Major General C. Van Straubenzee now commanding a Territorial Division and Major General C.C. Luard, commanding in China.

The original Staff of the College were:—

Colonel E. O. Hewitt, R.E. Commandant. (Later Maj.-General and C.M.G., Commandant S.M.E. and Governor of the "Shop," where he died).

Major J. Bramley Ridout, 90th Light Infantry, Captain of Cadets and later Adjutant and Secretary, as the Cadet Companies increased in number; afterwards well known in civic life at Chatham and father of Sir Dudley Ridout (late R.E.).

Major Edgar Kensington, R.A. Professor of Artillery and Mathematics. (Later very well known at the "Shop" as Professor of Artillery. Father of Lieut.-Col. G. B. Kensington, O.B.E., R.E., retired).

Major Hawkins, R.A. Professor of Fortification. This officer was relieved in 1877 by Lieut. G. R. Walker, R.E. (my father).

Lt.-Col. Oliver, R.A., *p.s.c.* Professor of Tactics and Topography. Joined in 1877. Succeeded Colonel Hewitt as Commandant.

Mr. Ferguson, Professor of German; M. Duval, Professor of French; and Mr. Foreshaw Day, Professor of Drawing.

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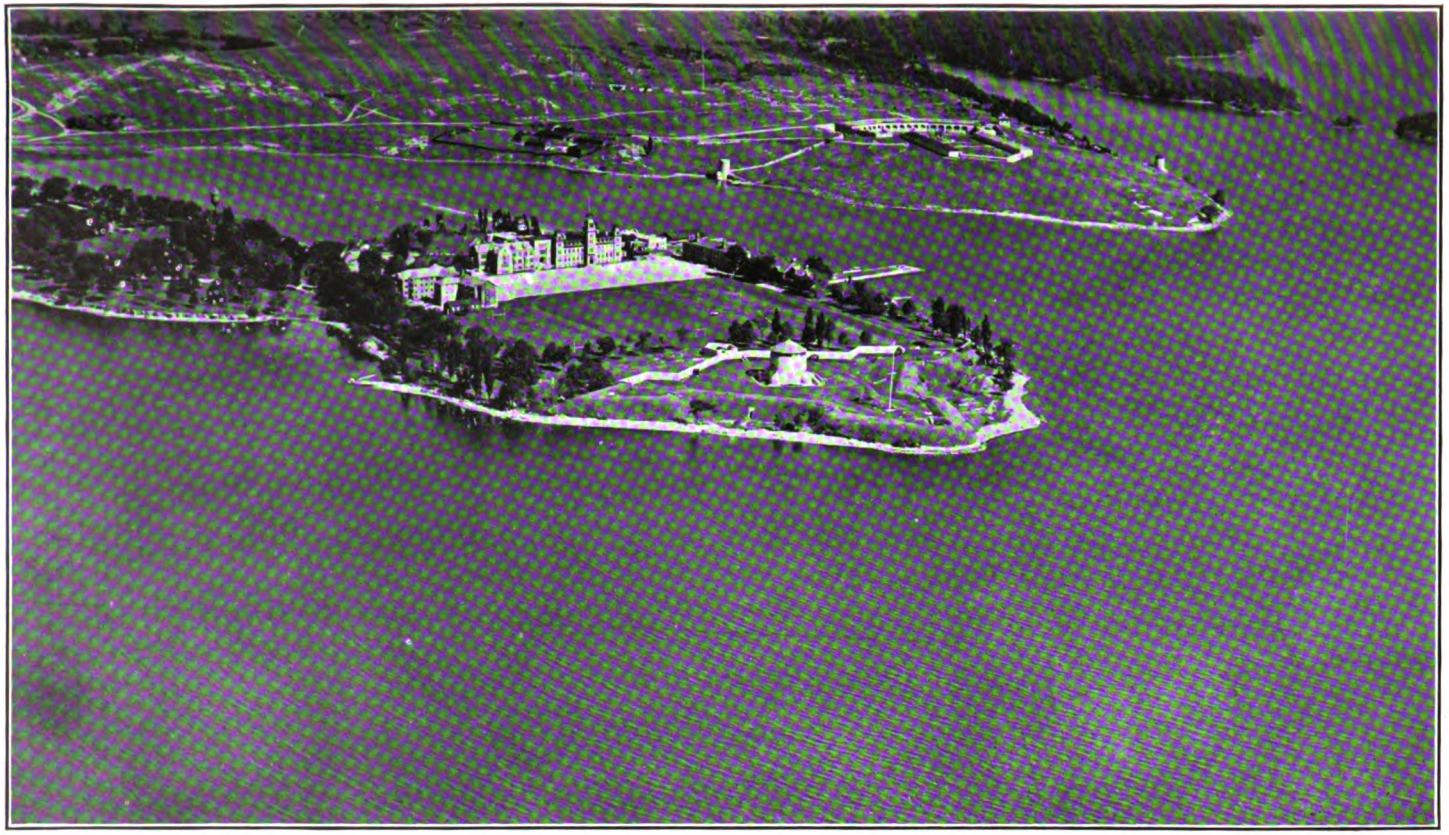

THE ROYAL MILITARY COLLEGE FROM THE AIR.

Showing the " Stone Frigate " on the right of the white parade. The Educational block facing the parade and the new living quarters on the left. At the point is Fort Frederick. On the point across the Bay is Fort Henry, down the slopes of which was the Toboggan Slide.

By kind permission of The Royal Military College of Canada Review and Log of H.M.S. Stone Frigate.

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The Staff gradually grew in numbers. In 1880, Lieut. M. H. P. R. Sankey, R.E., joined as Instructor in Fortification and assistant to Walker. He in later years became celebrated as an Electrical Engineer in England and was the father of Lt.-Col. C. E. P. Sankey, D.S.O., R.E., (retired). He died in London in 1926. Major "Sammy" Fairtlough, R.A., also joined Kensington, as his assistant, about this time. He died in Sierra Leone, in the nineties of the last century. Mr. Carr-Harris, father of Carr-Harris, R.E., was Professor of Civil Engineering. Mr. Baines was Professor of Science. Sankey left in 1882 and was relieved by Lieut. E. Raban, R.E., now Sir Edward Raban, K.C.B., K.B.E. Walker came home in 1883 and was succeeded by Raban, and Lieut. S. Davidson, R.E., went out in relief.

It is of interest also to note that the first graduate of the College to become Commandant, was Colonel Taylor, *p.s.c.*, Cheshire Regt., in 1905. The first Graduates to become instructors were Lieuts. A. G. Wurtele and J. B. Cochrane, both of the Canadian Army, in or about 1881.

Three members of the Subordinate Staff, should be mentioned: firstly, Regimental Sergt.-Major Mortimer, an old Horse Gunner, who had served in the Indian Mutiny, he was a small fiery man; secondly, Sergt. Morgan of the Scots Guards, the Gym. instructor, who joined in 1877; the third was Sergt.-Major Birtles, R.E., who took Field Works under my father, a man beloved and admired by all, a splendid type of the best that the Corps has produced.

The organisation of the College was based on a combination of the systems at the "Shop" and West Point. The youngest age of entry for cadets was 15. The Cadets were organised as a Battalion of two or three companies, each with its C.S.M. and Cadet N.C.O's., the Senior Cadet being called the Battalion Sergt.-Major. The course was of four years' duration. It was framed to afford a good Civil Engineering and Military Education.

The courses were:—

Civil Engineering. (Including a rather detailed course of Railway Construction and Bridging. A large number of the Cadets took up railway engineering as their life's work and succeeded in it. Girouard first got railway experience in Canada). Military Engineering. Artillery. Tactics and Topography, Civil Surveying and Astronomy. Mathematics (from Arithmetic to Calculus). Chemistry and Physics. Freehand Drawing and Sketching. French. German. Military Drill and Exercises.

As a larger number of Cadets went into civil than into military life, the education aimed at was to give a man a profession in civil life, so that he could earn money at once, and at the same time to lay the foundation well for military service if called upon. The value of this was apparent during the Great War.

My recollection is that the four years' course enabled the instruc-

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tion in all departments to be very thorough and that the Cadets when leaving were much better equipped for life than those who went through the colleges at home. In fact a Kingston Cadet, joining at Chatham in those days, had but little to learn technically. They were trained Civil Engineers with an excellent Military training also. All they lacked was practical experience.

The status of the Cadet was that of the private soldier. He was in fact an enlisted man and subject to Military Law like a soldier. In this he differed from his brethren at Woolwich and Sandhurst, who were only subject to their College rules.

The uniform, to use the words of the Army List, was "Scarlet, facings blue." It was very effective. A well laced red tunic for full dress and a red frock for work. The tunic is still retained and looks very smart. An "infantry grey" great coat with a red collar completed the rig.

The head-dresses were, full dress, a white helmet; undress, a round forage cap, similar to that which was worn at Woolwich. In winter the Cadets wore grey astrakhan caps and seal-skin gloves. The B.S.M's. and C.S.M's., however, wore astrakhan collars to their great coats and astrakhan gauntlets. A most effective get up.

When I first knew Kingston (1877), there were only three College buildings. The old "Stone Frigate" block, in which the Cadets lived, had been the winter quarters of the old Naval Establishment, abolished after the war of 1812; the new administrative and educational block, which was just finished, and a gymnasium. There were a couple of Instructors' houses and quarters for servants in the grounds.

The site was ideal, albeit rather treeless and bleak. It was isolated by water from the town and yet was close enough for convenience. There was ample ground for games. The Cadets played both cricket and Rugby football, tennis was in its infancy and golf unknown. They excelled in football, the cricket in those days was only mediocre I fancy. However, in summer the principal sport was boating and sailing, for which the Lake (Ontario) gave unrivalled facilities. I call it "the Lake," it was really a sea, on which any kind of weather might be expected. As a result, there were few cadets who were not really good watermen. In wintertime there were winter sports of all kinds. Snow shoeing, tobogganning at Fort Henry, skating and ice yachting. The Cadet Battalion used to be drilled on snow shoes on the snow-covered ice; rather a thrilling sight, to see them paddling round like a huge flock of ducks with enormous feet.

I think the discipline amongst the Cadets themselves was high. I have been told that the ceremony of "Initiation" for the last joined was one that could not be trifled with. Otherwise the life was very like the "Shop." Anyhow the results of the system were

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excellent and the graduates were turned out tough, reliable and self-reliant members of society. I doubt if you can ask anything more from an educational establishment.

I have said above that the R.M.C. Kingston is an Imperial asset. I think that anyone who met Canadian Troops during the Great War will agree with me. Wherever one met them they were good and wherever one met them one found Kingston graduates in high positions. The tone of the troops was the tone of Kingston; reliability and self reliance and the saving grace of humour. I will conclude with one war story of a Canadian Officer, who was serving under me in Ypres. He was a graduate of Kingston and a Mining Engineer, serving with a British Tunnelling Coy., R.E. He was a real tiger and feared nothing that walked.

We were having a lot of trouble with water in shafts and galleries, owing to inadequate means of tackling the difficulty. One particular shaft, in one of the Brigade Areas, was giving a lot of trouble. The Brigadier was as much concerned as I was. In the middle of one very wet night the accursed shaft collapsed, not for the first time, and the Canadian Officer went straightway to tell his Brigadier. He arrived at Brigade Headquarters about two a.m., knocked up the Brigade Major and asked to see the General.

When he was introduced into the presence, the Brigadier asked what was up and received the reply " General, that 'Goddam' Hole has fallen in again." The Brigade Major, who was rather of the crusted variety, nearly fainted and the Brigadier roared with laughter and, having refreshed his visitor, dismissed him with some words of encouragement. He christened the youth the " Goddam Fella," by which name he was generally known thereafter.

In conclusion I must acknowledge my indebtedness for some of the details in this paper to Quarter Master and Major T. H. Tennent, O.B.E., R.E. (retired), at whose suggestion, in fact, the article has been written.

Major General Sir Dudley Ridout has added the following note :— General Walker has not mentioned what an extraordinary influence his father had on the cadets and what we all owe to him. All the R.E. Instructors were really " Giants "—and it was to men like Sankey, Walker, Raban, Stuart Davidson, that the earlier cadets owe so much.

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THE RAISING AND LENGTHENING OF CARDINGTON AIRSHIP SHED AND OTHER WORKS.

By A. R. GIBBS, ESQ., A.M.INST.C.E., A.M.INST.M.E., OF THE DIRECTORATE OF WORKS AND BUILDINGS, AIR MINISTRY.

THE British Government decided in 1924 to proceed with the construction of two great airships, each of five million cubic feet capacity. This is more than twice the cubic capacity of any previous ship, and, no existing accommodation being suitable, the following "ground" works became necessary :—

(a) *Cardington, Bedfordshire.*
Enlargement of the existing airship shed, provision of a Mooring Mast and incidental works.

(*b*) *Ismailia, Egypt.*
Provision of a Mooring Mast and incidental works, and construction of hydrogen producing plant.

(c) *Karachi, India.*
Construction of a new Airship Station, provision of an Airship Shed, Mooring Mast and subsidiary services.

These works, which entail an expenditure of about £500,000, devolve upon the Directorate of Works and Buildings, Air Ministry, and are being carried out to meet the airship requirements of the Directorate of Airship Development.

The purpose of this article is to give an account of the enlargement of the Cardington Shed in particular, with a brief description of the works as a whole. Some of the works referred to at (*b*) and (*c*) are not yet completed.

CARDINGTON AIRSHIP SHED.

Description of the original shed.

The original shed was built for the Admiralty in 1916-17 and consisted of a steel framed structure, the cross section being in the form of a three-pin arch supported on "A" frames, as shown in Fig. 1.

The width between centres of pins was 181 feet 6 inches, width over all 254 feet, height to lower pins 63 feet 3 inches, minimum clear height at centre 110 feet, length 700 feet.

Capacity above floor level 17,100,000 cubic feet.

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The framing was covered with painted ungalvanized corrugated sheeting, with the exception of the walls to the annexes, which are "Hyrib" covered with cement mortar. Both ends of the building were fitted with sliding doors covering the entire height and width of the main transept; further particulars of these doors are dealt with later. The approaches to the shed were protected against prevailing winds by screens 70 ft. high and 700 ft. long.

Alterations decided upon.

In order to accommodate the new airship it was necessary to increase the length of the shed by four bays, viz., 112 ft., and increase the height by 35 ft. It was considered in the light of past experience that there was no necessity for doors to be fitted at both ends, and also that the screens were unnecessary. The sheeting of the shed was in bad condition and consequently was not re-used.

A general plan of the extended shed is shown in Fig. 3.

Tenders invited.

General designs and tenders for the enlargement of the shed were called for from competent firms, and the tender of the Cleveland Bridge and Engineering Co., Ltd., of Darlington, was accepted. The details of the construction proposed were examined in the Air Ministry.

Method of obtaining increased height.

Many ways of increasing the height presented themselves. It is understood that the contractors gave detailed consideration to a scheme for raising the shed bodily by a system of hydraulic jacks. This scheme was not pursued, in view of the considerable increase in height adopted, viz., 35 ft.; moreover, the existing building was an entirely bolted structure and lent itself to easy dismantling.

The contractors were at a disadvantage, inasmuch as they had not erected the original structure, and had no knowledge of the actual setting out of holes, etc., in the members against which the new steelwork had to be bolted. The wisdom of dismantling the shed was confirmed in practice when it was found necessary to correct irregularities in the original structure, built during the progress of the war, when skilled labour was not easily obtained.

The method adopted is shown in Fig. 2, where it will be noted that the vertical columns are strengthened and increased in height. The spandril pins of the arch are carried 35 ft. higher than in the original building, but otherwise the roof remains unaltered. Stability is provided for by the new raking struts running from the raised springing points of the arch down to new blocks of concrete constructed outside the existing foundations.

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These raking struts are braced to the existing framework to give them lateral strength.

Further diagonal and horizontal bracings have been introduced between the main transverse ribs of the building in its longitudinal planes to supply them with additional rigidity, necessitated by the increased height. These bracings are indicated in Fig. 7.

The original shed had a comparatively flat top to the main door openings, having been designed to accommodate two airships of the R.33 type. In order to give greater height in the centre (for the new single ship) it was decided to remove the wind girder which supported the end sheeting over the doorway, and to carry this sheeting by smaller framing.

This gave an additional headway at the centre of about eleven feet, which, added to the 35 ft. gained by raising the roof, gave a total increase at the centre of the doorway of 46 ft. This is, therefore, the effective increase in height of the new building over the old.

The increased height meant greater loads, and the foundations under the existing inside columns were, therefore, increased from 7 ft. 6 in. by 7ft. 6 in. to 11 ft. 6 in. by 11 ft. 6 in. A trench was cut round the existing concrete to its full depth, the concrete being hacked and roughened on all sides so that the entire surface should form a good bond with the new concrete. The new concrete, consisting of one Portland cement to six of aggregate, was then deposited and vertical and horizontal reinforcement was inserted, so as to ensure that the new and old concrete should act as one homogeneous mass.

The foundations at the south-west end are on gravel, but towards the north-east end the clay rises to within a foot or two of the surface and most of the foundations are, therefore, in clay, the depths averaging about 6 ft. The load on the virgin soil does not exceed 1½ tons per sq. ft.

Lengthening the Shed.

The lengthening of the shed was a simpler matter than the raising of it, as it was possible to adopt a design distinct from the existing shed. The arch rib with one or two improvements is identical with those in the original structure, but the new "A" frames are naturally of a less complicated form than those formed of new and old work. A section through the extension is given at Fig. 5.

Designing Data.

The shed, as rebuilt, has been designed to the following data:

Wind. Thirty-five lbs. per sq. ft. horizontal on roof, 30 lbs. per sq. ft. on sides, ends and doors.

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The normal pressure on sloping surfaces was calculated by Prof. Unwin's formula. The above loads were considered sufficient to cover any effects of suction on the lee side.

Snow. Five lbs. per sq. ft. of surface covered (this was taken in addition to wind).

Stresses in Steel.

Tension. The tensile stress was calculated on the nett area, *i.e.*, after deducting holes, and is not greater than 7 tons per sq. in. for dead weight of structure and 8 tons per sq. inch for wind and snow.

The above corresponds to a factor of safety of 4 for dead weight and $3\frac{1}{2}$ for wind and snow.

(For simplicity, wind and snow loads were reduced in the calculations for steelwork to a dead load basis by multiplying by $\frac{7}{8}$).

Compression. The compressive stress on the gross section is not greater than 85 per cent. of the corresponding tensile stress (*e.g.*, 85 per cent. of 7 tons=6 tons) nor more than that corresponding to the ratio given by Fidler's formula for compression members.

Reversal of Stress. In no member subject to reversal of stress does the range exceed 12 tons per sq. in.

Shearing. The shearing stress on rivets or turned bolts of a driving fit does not exceed three-fourths of the permissible tensile stress, *i.e.*, $5\frac{1}{4}$ tons; double shear was taken as $1\frac{3}{4}$ times single shear, viz., 9 tons.

For black bolts the permissible stress was decreased to 4 tons and 7 tons per sq. in., respectively.

Bearing. The bearing or bending stress on rivets or turned bolts of a driving fit does not exceed 10 tons per sq. in.

Struts and Columns. Claxton Fidler's formula was used. Struts were generally assumed to be fixed at one end and hinged at the other, unless they were hinged at both ends.

Quality of Steel. The steel used was in accordance with the *British Standard Specification for Girder Bridges*, Parts 1 and 2, No. 153, and manufactured by Process A.

Calculations.

The original framework of the shed, from a practical point of view, was a determinate structure. There is, of course, some doubt as to the distribution of the horizontal thrust between the

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two legs of the annexe, but this is not a difficult matter to deal with in practice. The addition of new steelwork to the existing framework was a more difficult problem. It was not possible to design the new raking strut economically without bracing it to the existing steelwork. Fig. 4 illustrates the framework in outline and shows the method adopted in making the calculations, together with resultant stresses.

The trestle as heightened is treated as a unit, and the loads applied at panel points as shown. The members shown dotted were assumed not to assist when arriving at the stresses in other members. The possibility of the whole of the load coming down the new raking strut, instead of being divided between the raker and the outer vertical member of the porch annexe, was investigated and provided for.

Manner of Procedure.

The contractors commenced work at the north-east end of the shed, and after laying extensions to the Air Ministry railway sidings, proceeded to erect a Butters' steam crane, with 140 ft. jib, on a 40 ft. steel staging. This crane could lift 7 tons at 90 ft. radius and was used to erect the great steel travelling stage shown in Photo 1.

The large stage was 100 ft. wide, 80 ft. deep and 120 ft. high, and contained 230 tons of steel; it was built on a double track, 90 ft. centres, and was moved forward by means of wire ropes operated by winches secured to the longitudinal sleeper tracks. Two 10 ton Morgan steam cranes with 110 ft. jibs were mounted on top of the staging. These cranes lift 10 tons at 70 ft. radius.

Incidentally it may be mentioned that one of these cranes was first erected on the ground, and used to erect the steam crane with 140 ft. jib previously referred to.

The travelling stage was first moved forward into a convenient position for dismantling the doors at the N.E. end, the steelwork of which was lowered to the ground and dissembled for transport to Darlington, where much of the framework was adapted to form the frames for the new permanent end of the extended building. The stage was again moved forward, and the removal of the main arch ribs which form the roof was commenced, the stripping of the sheeting, purlins, etc., being kept in advance of the dismantling of the framework. The main ribs were removed in sections and stacked at the side of the shed or laid down flat on the concrete floor.

This process continued down to the south-west end of the shed, as shown in Photo 2. While this was proceeding the 5 tons Butters' crane was removed from the 40 ft. stage and re-erected on the ground at the opposite end of the shed in a convenient position

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for dismantling the S.W. doors; these doors were then forwarded to Darlington for reconstruction.

After remodelling at the contractors' works the doors were re-erected, partly by means of the stage and partly with the 5 tons jib crane (see Photo 3). Whilst the work already described was proceeding, the new concrete foundations were put in, and the vertical columns under the arch pins were strengthened by the addition of a 9in. by 3in. channel, bolted on the face of the existing column, the holes in the existing work being drilled *in situ;* and new steelwork was fabricated at Darlington.

Drilling on the site was carried out with electrically-operated drills, and rivetting was performed with pneumatic rivetters.

After completion of the new main doors, the new raking struts, annexe bracings, etc., were erected by means of the stage for a length of about 300 ft. The top of the stage having been raised 35 feet by an additional platform. (See Photo 4.)

The staging was then brought forward again to the S.W. end, and the arch ribs, subsidiary bracing, sheeting, etc., for this portion of the building were completed while the stage worked once again towards the N.E. end.

This procedure was adopted as the Airship Authorities desired to utilize the first 300 ft. of the shed as early as possible. The erection of the raking struts, re-erection of main ribs, etc., was carried out in an almost identical manner to that described hereafter for the lengthening of the building.

The order adopted for the erection of the trestles in the extended length of the building can be followed from the photographs. In Photo 5 the inner vertical column nearest the foreground has been erected to a height of about 45ft., and on the extreme right of the photograph can be seen the first portion of one of the rakers which has just been placed in position by the crane. The next stage in the erection of a trestle can be observed from Photo 6, and the erection of the top section of the trestle is shown in Photo 7.

The three pin arch rib was erected throughout in four sections, no section weighing more than about 5 tons. The cranes were capable of lifting one-half section of the rib into position in one piece, but the contractor considered it more satisfactory to handle lighter loads. Photo 8 illustrates the procedure adopted. It will be observed that the first section has been raised into position and the pin connecting it to the top of the "A" frame has been inserted, while the other end of the section is temporarily supported on the top platform of the stage.

The crane has lifted the second section of the rib from the ground, and is just about to lower this portion into position, while the men are waiting to insert the connecting bolts. The two cranes

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on the stage enable the two sides of the rib to be erected simultaneously.

The erection of the fixed end of the shed was carried out by means of the stage, on similar lines to those adopted for the "A" frames and, therefore, calls for no detailed description.

The dismantling of the temporary plant followed the reverse procedure from that adopted for its erection. The 7 tons crane with 140ft. jib was erected once again on its 40ft. staging by means of the travelling stage. This latter was then dissembled by the former, and subsequently the former itself was dissembled by one of the jib cranes which had been removed from the top of the stage.

Main Doors.

The doors to the original shed were of the self-supporting or ballasted type, in four leaves, and were operated by means of a capstan on each leaf.

The doors took about half-an-hour to open, and required the efforts of a large number of men.

The loads on the wheels, under the worst assumed conditions, viz., 30 lb. per sq. ft. wind, amounted to about 60 tons per wheel, and under the most favourable conditions, *i.e.*, without any wind, 33 tons per wheel.

These high loads made the operation of the doors difficult, and rendered it impossible to retain the existing base framing for the heightened doors; opportunity was, therefore, taken to entirely remodel them.

The new doors are of similar type to the old, but being 46ft. higher demanded an increased width of base and track. The old track, consisting of single lines at 36ft. centres, was taken up, and a new one put down consisting of two 3ft. 6in. gauge ways at 60ft. centres. Each rail is formed out of a 3½in by 1½in. billet machined and rivetted to a girder (running the whole length) consisting of two 10in. by 3½in. channels with a 9in. by ½in flange plate. The 3ft. 6in. gauge is maintained by transverse bearers of 4in. by 3in. by ⅜in. angles at about 3ft. centres, the whole being embedded in concrete as shown in Fig. 8.

It will be observed from Photo 3 that there are four leaves to the new doors, and each leaf consists of horizontal girders carrying a facing of galvanized corrugated sheeting, the girders being supported by two tall "A" frames. The four legs of the "A" frames are secured to the horizontal girders forming the base frame or platform of the doors, and stability is ensured by the concrete filling deposited *in situ* between the main girders of the base frame. The total weight of each leaf, including the platform and ballast, is carried by four pivots, secured to the platform, and each of

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these pivots rests in the pocket of a steel casting bridging the bogie frames, the pivot allowing sufficient movement to ensure that the load from each leg is carried by a bogie, and distributed evenly over the four wheels (see Fig. 8). This arrangement avoids the difficulty experienced in the earlier types, where the rigidity of the base, and arrangement of the wheels, prevented an even distribution of the loading. The wheels are double flanged 2ft. 6in. diameter tread, made of cast steel with roller bearings in gunmetal cages. The wheels have turned treads and are fitted with hard steel bushes. The shafts are provided with hard steel sleeves shrunk on.

Each pair of leaves weighs 222 tons, and carries about 248 tons of concrete ballast, making a total load of 470 tons for each half of the door, or a total of 940 tons for the whole door. With no wind, the load on any wheel would not exceed 15 tons, and with a wind of 30 lb. per sq. ft. the maximum load would not be greater than 30 tons per wheel. An illustration of the bogies is given at Photo 9.

Although the door is divided into four leaves for the purpose of articulation, the two leaves on each side of the centre line are linked together and operated as one. Each pair of leaves is operated by hand power and chain gearing, six men being able to open the two leaves in about ten minutes. The chain by which each pair of leaves is operated is situated under the base frame on a longitudinal line between the two bogie tracks and is anchored at each end. The chain passes up through the base of the door on to a winch fixed on the door frame.

The completed Shed.

The completed shed has a floor area of $4\frac{3}{4}$ acres and a capacity of 26,600,000 cubic ft. The clear width is 180ft., up to a height of 98ft., the maximum clear height at centre being 156ft. 8in The total height to crown pin 174ft. 6in. and height over all 179ft. 6in. The total inside length of the shed is 812ft. The floor is of concrete and fitted with mooring rings and trenches for carrying the pipes for watering, gassing and fuelling the ship. The sides of the shed are sheeted with 20-gauge galvanized corrugated sheeting and the roofing is covered with 22-gauge $3\frac{1}{2}$in. pitch Robertsons' protected metal.

Eleven doors are provided to the shed to give access thereto for men and materials. One door, 18ft. 6in. by 18ft. 6in., is placed in the end of the building for the transport of larger material.

The building is lighted by five rows of glazing each side of the shed and also at the new end. The existing anti-actinic glass was replaced, but the ordinary wired rough rolled plate was used in the new glazing to save expense, as it is considered that, in the

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future, the time during which a ship is in the shed will be small compared with the time spent at the mast and in flying.

Artificial lighting is provided by ordinary electric lamps in gas-tight fittings. Portable flood lights are to be provided for illuminating any required portion of the ship.

Three internal longitudinal gangways run the whole length of the roof, and access from one to the other can be obtained by means of any of the three transverse gangways. Access to the lower gangways is given by three staircases on each side of the shed. An outside ladder is provided down one of the raking columns to the N.E. end, with a doorway at the top leading to the gangway, to provide a way of escape in case of emergency.

Two outside runways are provided at the eaves of the roof to carry cradles for painters, glaziers, etc. Six internal runways are supported from the roof, each of which runs the whole length of the building, and is capable of lifting four tons vertically, and withstanding at the same time a horizontal component of one ton.

Opening and closing louvres have been fitted the whole length of the shed, for ventilation and to prevent accumulation of gas escaping from the ship.

The roof is drained into pressed steel gutters at eaves level, and from thence into six mild steel tanks situated in the roof; each tank is of 7,000 gallons capacity and is joined up to service pipes connected to eight fire hydrants.

The total weight of steelwork in the framework of the completed shed amounts to about 3,720 tons, exclusive of foundation steelwork.

The cost of the alterations is equivalent to about $2\frac{1}{2}d.$ per cubic foot of added capacity.

The work has been executed most satisfactorily by The Cleveland Bridge and Engineering Co., Ltd., of Darlington. It was commenced in October, 1924, and completed in May, 1926, and it is pleasant to record that although the work has been carried on in all weathers, no serious accident has occurred.

MOORING MASTS.

The mooring masts are steel-framed structures 200 ft. high, the eight supporting columns forming at the base an octagonal plan 70 ft. across. The passenger platform, from which passengers will embark, is 40 ft. diameter and 170 ft. above the ground. Above the passenger platform is a circular turret 25 ft. diameter, with a conical roof in which is housed the mast head and its machinery. The mast is designed to safely withstand a pull from the ship of 30 tons in any direction.

The machinery house, at the base of the mast, houses three steam winches, each capable of exerting a pull of 15 tons. These winches are provided with remote controls to enable them to be operated

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from the passenger platform at top of mast. Pumps are installed for pumping ballasting water to the ship at a rate of 5,000 gallons per hour, and a 12-in. gas main runs up the mast for the re-gassing of the ship.

A photograph of the mast at Cardington is shown at Photo 10.

A ten-thousand-gallons fuel storage installation is arranged at the base of the mast, the tank being in an underground concrete chamber. The pump for this installation is capable of raising 2,000 gallons per hour of petrol or other fuel to a height of 400 ft.

The mooring masts for all three stations are similar, and in each case the incidental works include the laying of long lengths of gas and water mains, road, etc.

Hydrogen Producing Plant, Ismailia.

The Silicol system, which has been adopted for the hydrogen producing plant, depends upon the chemical re-action which takes place when powdered ferro-silicol (stirred with water) is gradually admitted into a chamber containing a hot strong solution of caustic soda. This re-action is very rapid and produces a very pure hydrogen, leaving a sludge formed of sodium silicate and uncombined soda. The proportion of silicol to soda generally used for gas production is about one to two.

The chemicals from which the gas is manufactured in this system are expensive, but the initial cost of the plant is much less than for the iron contact system. For intermittent use and during an experimental period, it is, therefore, economical. In the installation at Ismailia the gas producers have been made in two distinct units, so that the plant can be worked at half capacity when so desired. When both plants are working it is rated to produce 60,000 cubic feet per hour or a million cubic feet per day.

The plant is installed in a steel-framed building, and the lifts, pumps, stirring gears, etc., are electrically operated. Storage accommodation is provided in adjacent buildings, silicol being stored on the one side and caustic soda on the other. The installation includes a gas holder, water cooling tower, etc.

The plant has been designed and constructed by S. Cutler and Sons, Ltd., of Millwall, who have had considerable experience in this type of plant.

Karachi Airship Shed.

The airship shed at Karachi will be constructed of three pin arch ribs of 230 ft. span, the top pin being 200 ft. above ground level. An outline of the main rib, together with the Cardington main rib, is shown at Fig. 9, compared with well-known structures. The structure, when completed, will be the largest of its kind in the British Empire.

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CONCLUSION.

The whole of the works described in this article are being carried out under the direction of Major-General Sir William Liddell, K.C.M.G., C.B., Director of Works and Buildings, Air Ministry, and H. E. Oakley, Esq., C.B.E., M.INST.C.E., Deputy Director of the same Department. The writer is in charge of the Airship Development Section of the Directorate and directly responsible for the administration and execution of the works.

The Resident Engineer for the works at Cardington was Captain R. D. Thomas Jones, R.E. Reserve, M.INST.C.E., M.INST.M.E.

In conclusion, the writer wishes to record his thanks to the Air Council and the Director of Works and Buildings for permission to publish the particulars given in this article.

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CARDINGTON AIRSHIP SHED.

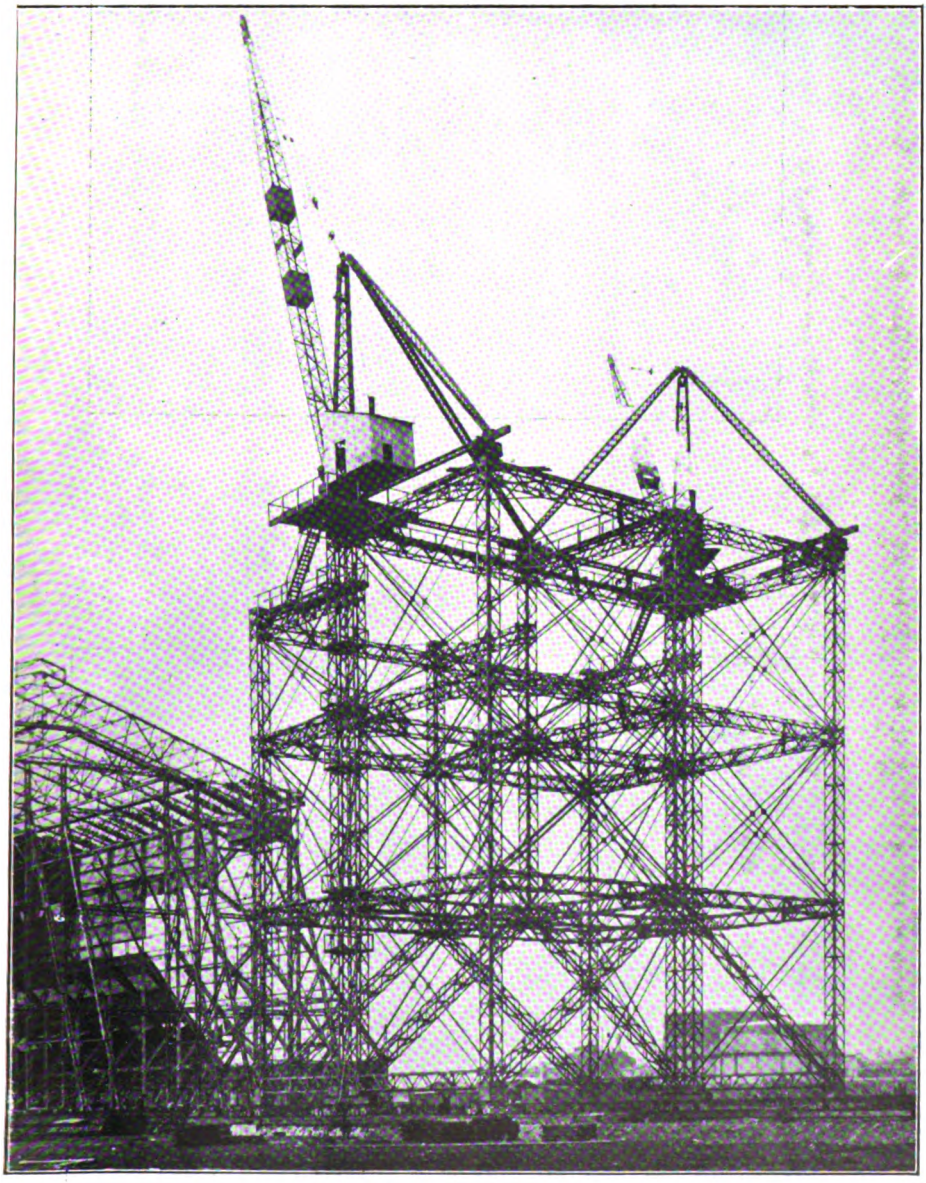

Photo 1. Travelling Stage.

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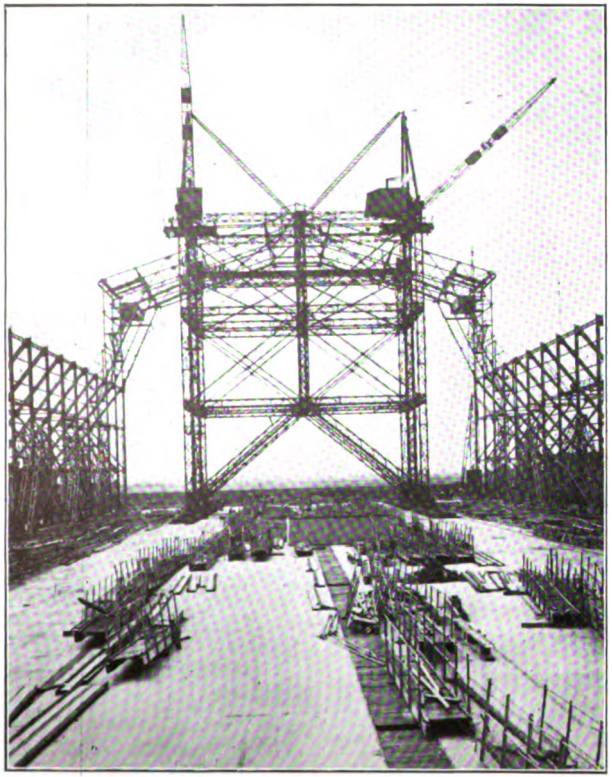

Photo 2. Shed, Roof nearly completely removed.

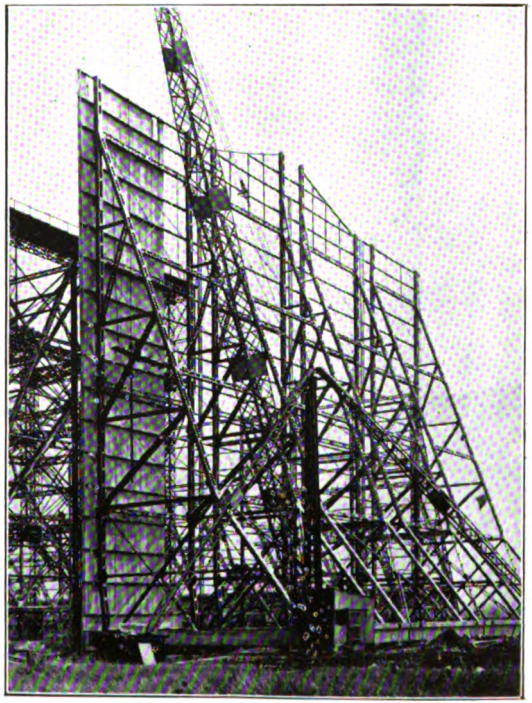

Photo 3. Five tons Jib Crane and Main Doors in course of erection.

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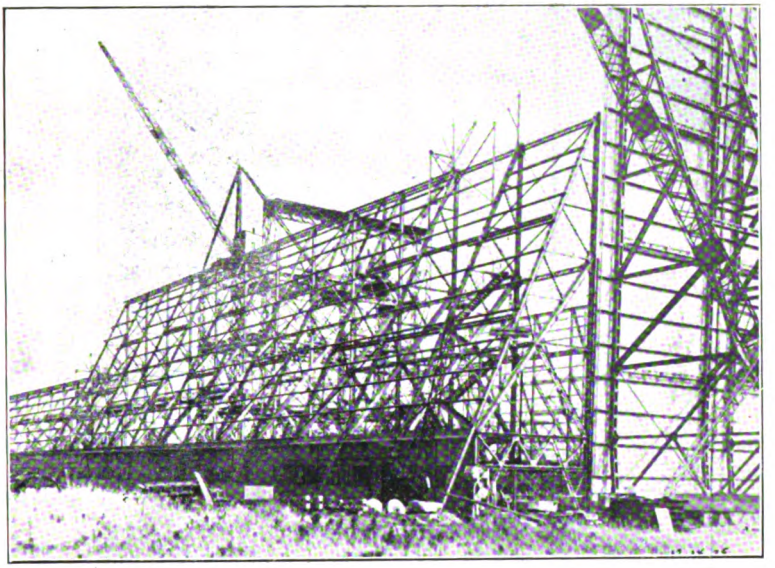

Photo 4. Shed, showing new Rakers to old portion of Shed in course of erection.

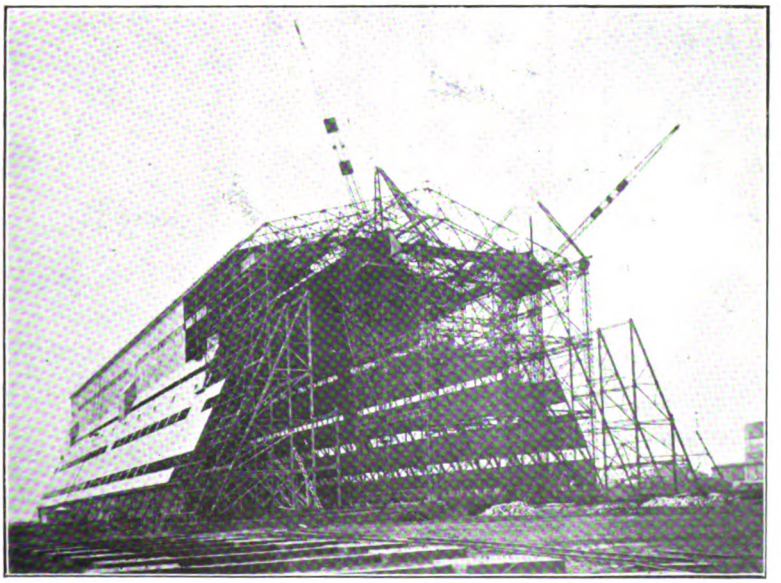

Photo 5. Shed, showing new "A" Frames to extensions in course of erection.

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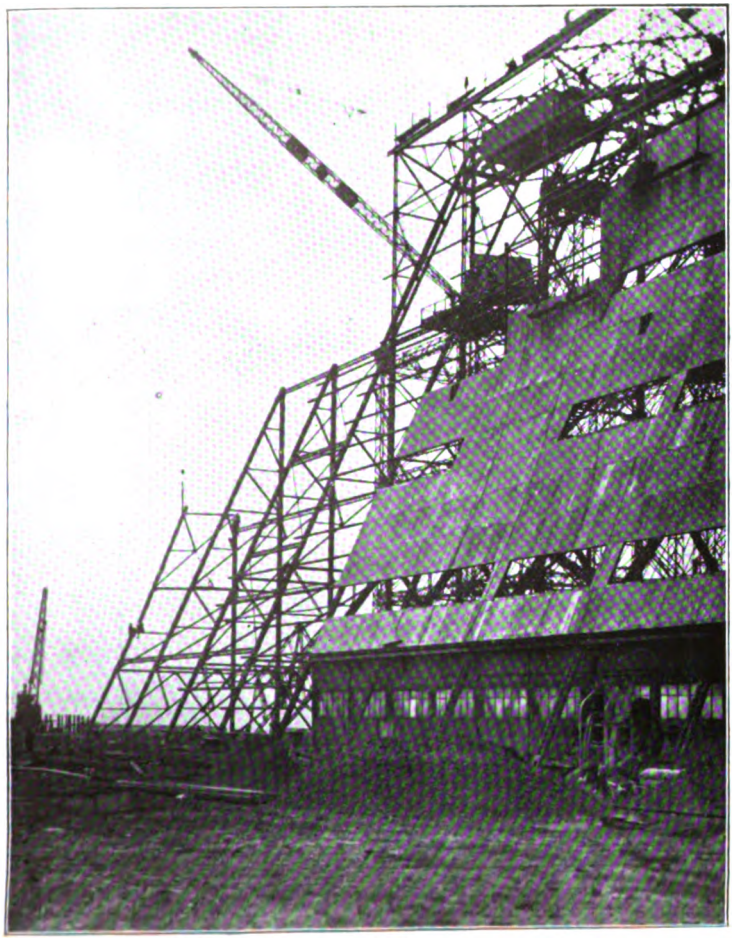

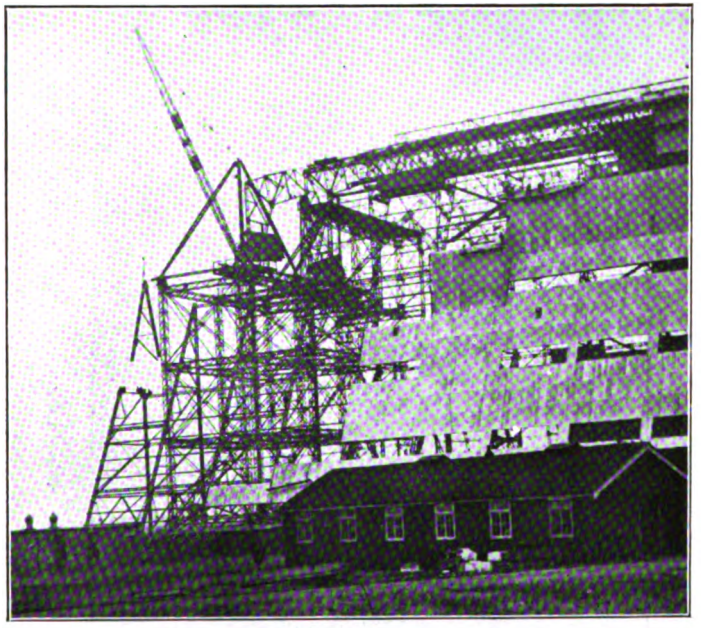

Photo 7. Shed, showing new "A" Frames to extension in course of erection.

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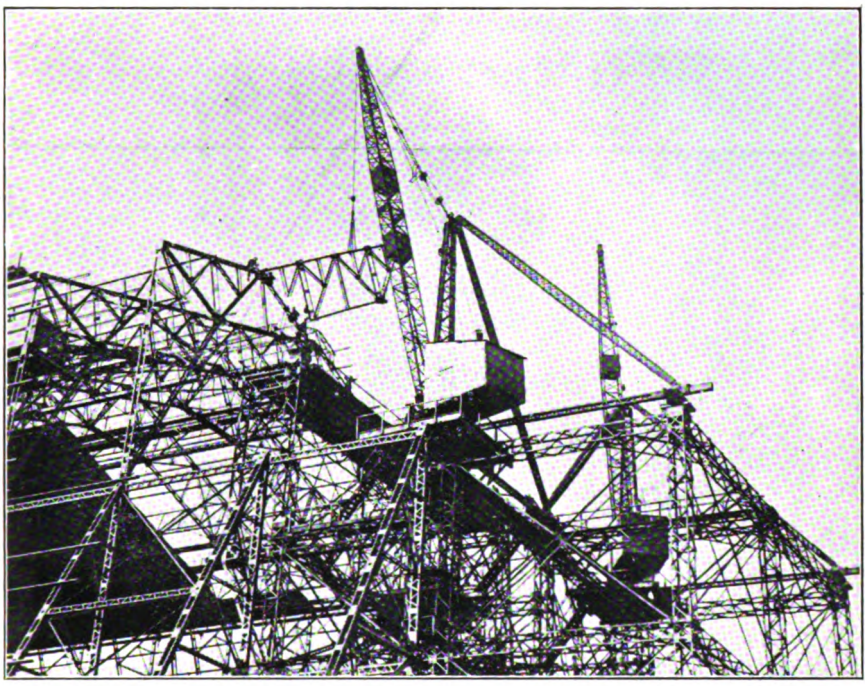

Photo 8. Shed, showing Sections of Roof being hoisted into position.

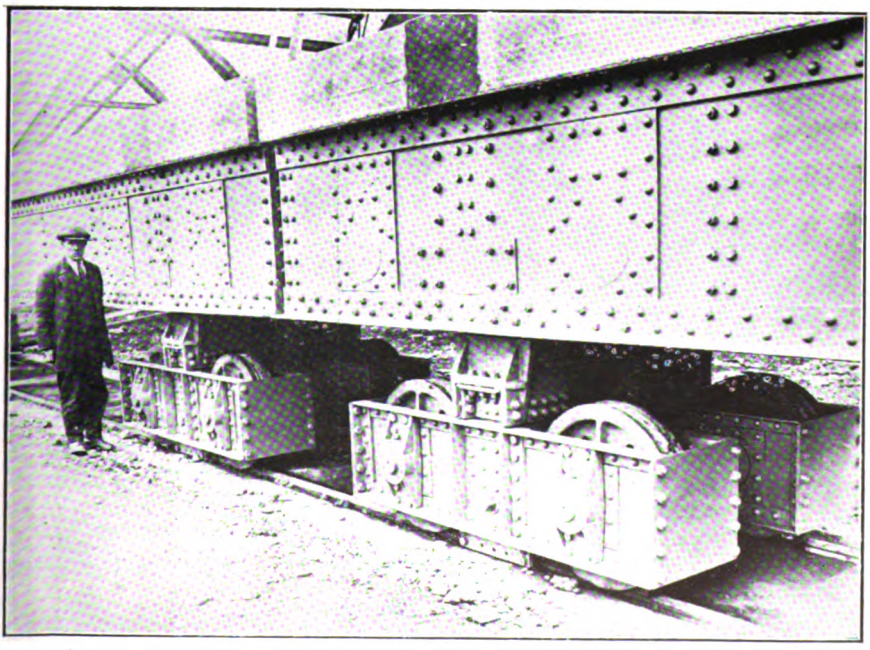

Photo 9. Part of Bogie Carriage to Main Doors.

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Photo 10. Cardington Airship Mooring Mast.

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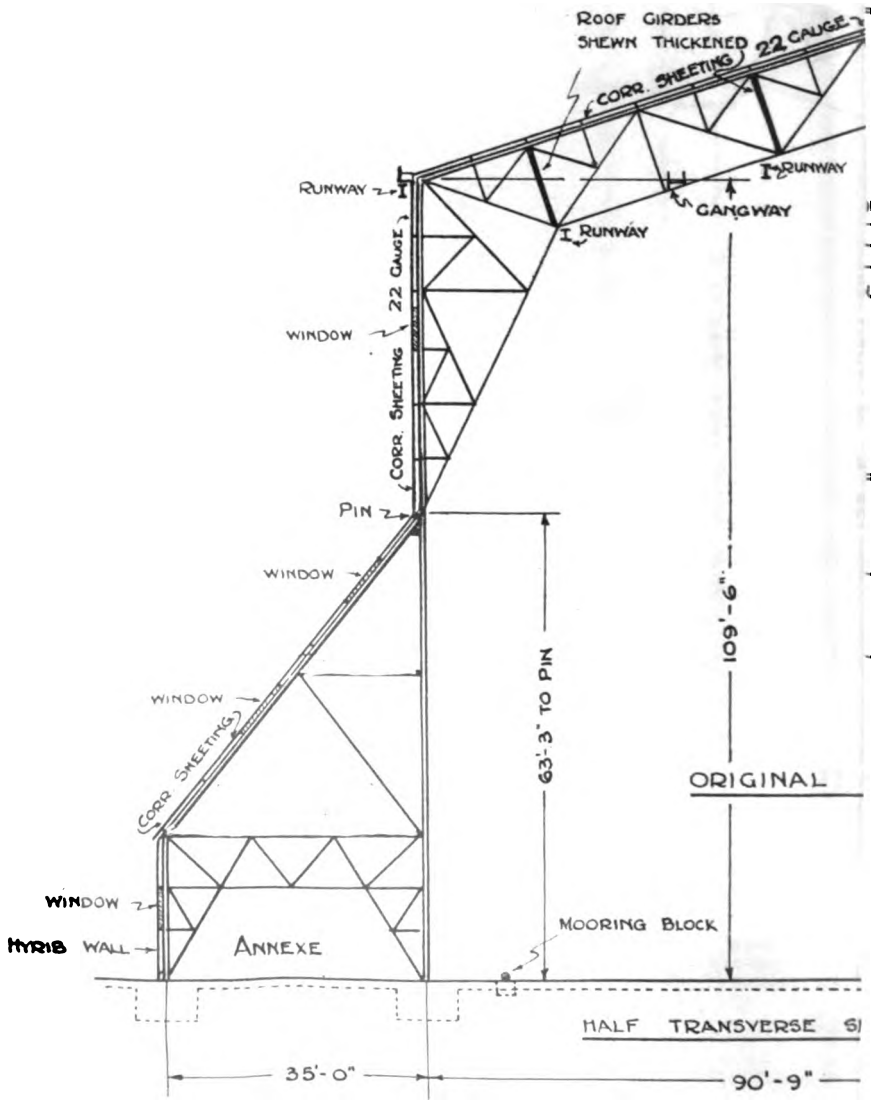

FIG. 1

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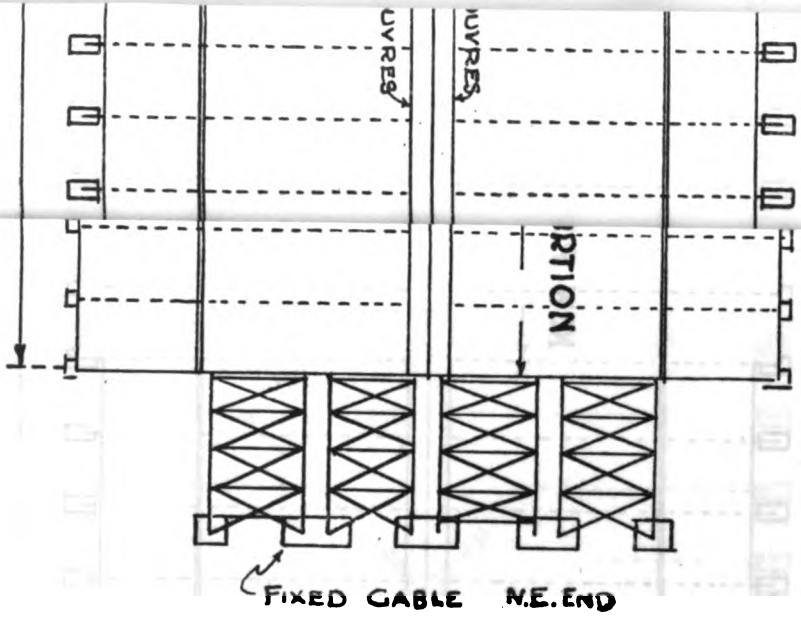

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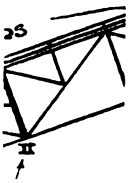


RUNWAYS.
GANGWAY

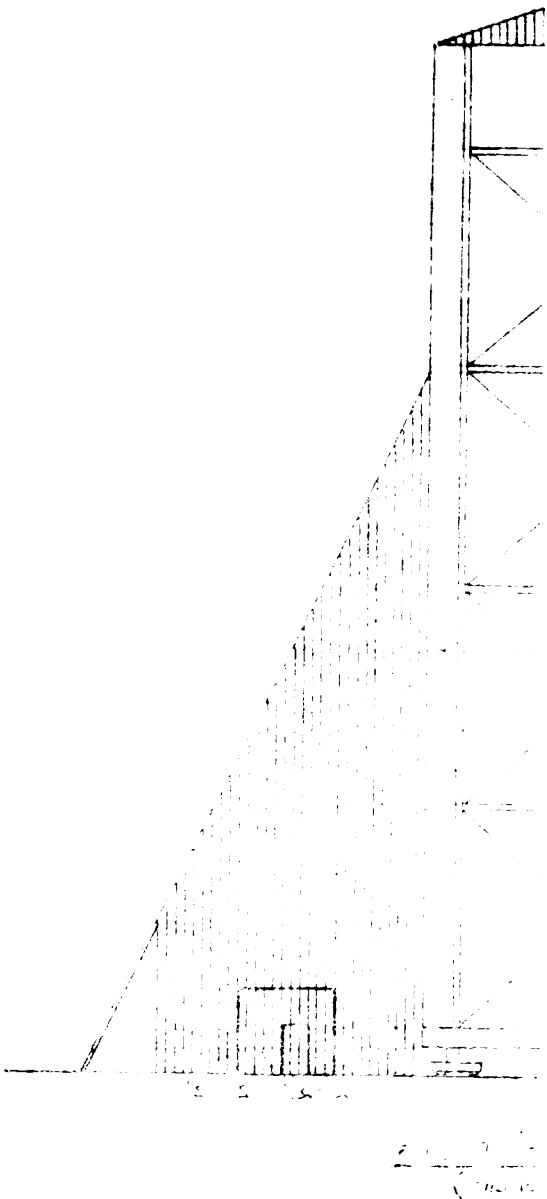
ITUATED AT
OF SHEE

= 180'-0"

E BETWEEN
= 180'-5"

9"

OF SHEE



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PICTURE-TELEGRAPHY AND ELECTRICAL VISION.

By COLONEL F. A. ILES, C.B.E., D.S.O., R. of O.

By the aid of the telegraphy of everyday use the thought of one human being reaches the mind of another human being at a distance by the following process. The thought has to be expressed in visible form (generally hand-writing), to be put into code by the telegraphist, to travel along a wire as a series of currents, which announce their presence acoustically to the receiving operator, who de-codes what he hears, and puts the de-code into hand-writing again, when it is ready for the addressee. This is what telegraphy, or " writing at a distance " arrives at, and it is achieved whether the spaced clicks heard by the receiving operator are made on a telegraph sounder by means of changes in line-currents, or made on a telephone-diaphragm, by means of changes in the currents set up in an oscillating circuit as a result of incoming etheric disturbances. In other words, it applies to wireless telegraphy as well as to telegraphy over wires. It is characteristic of this system of conveying messages that it is *indirect*, in that code has to be used.

The transference of pictures to a distance by electrical means is carried out by various methods which fall into two main classes, indirect and direct. Of these, the former is done like the ordinary telegraphy of commerce through the intermediary of code, actually of the same code. The *indirect* methods of picture-transference may therefore fairly be called Picture-Telegraphy, since the medium used is Morse. The *direct* transference of pictures to a distance by electrical means is performed without the intermediary of code and results in the production of fac-similes. As it reproduces the original hand-writing this system is more truly telegraphy, or " writing at a distance " than either ordinary telegraphy or picture-telegraphy by an indirect method, both of which can only produce at the receiving-terminal local interpretations of ideas which were received in code. We will therefore call picture-transference by electrical means picture-telegraphy whether the picture is transferred directly or indirectly. In the latter case it has as good a claim to the title of telegraphy as ordinary telegraphy, and in the former case a better one.

One of the first usages to which an indirect method was put —and this dates back 40 years—was the sending of military sketches. A method of numbering squares having been agreed upon, *e.g.*, letters in one direction and numerals in the other,

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the sketch was described in a message which could be handed in for transmission as a telegram, *e.g.*, North Point, g8, h1. Road h8, b2. Road, e6, d6, b6, a7. River, b8, c7, d6, d5, c5, b4, a3. Bridge, d5. Wood, and so on. Although adequate for rough black and white work, when no other method of transferring the picture was available, this system had to be improved when it was a question of dealing with photographs. In this case a scale of brightness values was drawn up, ranging from white to black through as many shades as the human eye could be trained to appreciate. A transparent squared paper was laid over the picture to be sent and to each square was allotted a letter of the alphabet corresponding to the mean brightness-value of the portion of the picture it enclosed. The letters were then telegraphed in an agreed order, *e.g.*, 10a, 5b, 6c, might mean " the top row starting from the left has the first 10 squares white, the next 5 squares of the lightest shade, the next 6 squares of the next shade," and so on. A rough picture was then put together at the receiving-terminal to accord with the telegram received. With small enough squares a picture more or less resembling the original was produced. The system was tried out between New York and Chicago as far back as 1910, and improvements were shortly forthcoming. Firstly, the number of brightness-values was increased from 3 in the first trials to 6 or 8. Secondly, a Selenium-cell was made to do the work of gauging the brightness-values, thus eliminating the errors of human eye and judgment. Thirdly, transmission was made automatic and the use of High Speed Telegraphy made possible by causing the Selenium-cell to work a number of electro-magnets, each corresponding to a degree of brightness, and thus to punch holes in a strip. Fourthly, reproduction was made semi-automatic, by means of a special typewriter recording only brightness-values, or even automatic, by making the punched strip reproduce the picture.

While the indirect methods of Picture-Telegraphy cannot compare with the direct methods as regards accurate and clear results, they cannot be lost sight of owing to certain solid advantages they possess. These are :—

(i) The message conveying the details of the picture can be sent and delivered as an ordinary telegram, being dealt with by the G.P.O. in their usual routine.

(ii) The difficulty of arranging for synchronization of sender and receiver in the offices concerned does not arise.

(iii) The necessity and expense of providing or hiring long-distance circuits between the offices concerned does not exist.

(iv) In certain cases direct methods are not possible.

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It is probable, therefore, that indirect methods of picture-transference will always have a place to fill, and if, as seems likely, the present efforts to apply high speed telegraphy to wireless are successful, indirect methods of picture-transference may in future receive more attention than at present, owing to the cheapening of long telegrams.

Direct Methods of Picture-Telegraphy.

The introduction of the direct method, that is the eliminating of the Morse Code as a vehicle of picture-transference by wires or wireless, is due to the light-sensitive cell; the most important example of which is the so-called Selenium "cell." By "cell" is commonly understood an arrangement of portions of certain materials in such a way that a difference of electrical pressure is set up in it by chemical means. This difference of electrical pressure is discoverable and available to do work when certain tappable points are connected up outside the cell. The cell is thus a means of producing electro-motive force. This definition covers the primary cell and the secondary cell, and it covers a certain type of light-sensitive cell in which the effect of light is to start chemical action, but it does not cover the class of light-sensitive cell of which the Selenium-cell is the prototype. Such a cell is to be regarded not as a source of electro-motive force but as a variable resistance, whose function it is to affect the current passing through it from an external source of e.m.f. As the Selenium-cell effects changes in current strength of the current that is passing through it, by means of its own varying resistance, and as such variation of resistance is due, not to manipulation of plug or handle, but to changes in the intensity of light falling upon it, it is also in a way a converter. It converts light of varying intensity into electrical currents of varying intensity. There have been several theories to account for the peculiar behaviour of Selenium in changing its electrical resistance under varying degrees of illumination. It is believed by some, though this explanation does not carry one very far, to be due to its being allotropic, and to the existence of different forms of it in the one specimen. In this connection it is not without interest to note that other substances which behave to light as Selenium does, include crystalline sulphur and lamp-black, and that both sulphur and carbon are also allotropic. Whatever the real explanation is, the facts remain. Selenium, belonging to the sulphur group, is obtained in its red amorphous form as one of the by-products in the manufacture of Sulphuric Acid. When it is heated it turns into a black glassy mass. In neither of these states is Selenium a conductor of electricity. On being further heated it crystallizes in grey crystals and becomes a fair conductor of electricity, possessing the remarkable property that its degree

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of resistance to the passage of a current varies with the degree of illumination to which it is subjected. It does not change its resistance in direct proportion to the light intensity, nor does it respond to a change of light without inertia, and both of these are grave drawbacks to its use as a converter. Also its behaviour is not constant and there is much scrapping of cells. Further its resistance is high. This latter objection to its use mattered formerly very much, but is now, since current amplification by means of valves has arrived, the least of the four evils. A common form of Selenium-cell consists of two metallic electrodes wound spirally and fairly far apart on a piece of slate, on one side of which the space between the wires is filled in with crystalline selenium. It is the function of such a cell in picture-telegraphy to convert optical values into electrical values at the sender, and electrical values into optical values at the receiver. In so doing it replaces the human operator and his code.

OTHER FORMS OF LIGHT-SENSITIVE CELL.

The Alkali-cells, depending upon a different phenomenon, form another important class of light-sensitive cell. The phenomenon in this case is the Hallwachs effect, viz., that if in a vacuum tube with a platinum wire anode and a special large cathode of potassium or other alkali, a high-tension battery is put in circuit in the usual manner and the cathode subjected to light of differing intensity, the changes in the light cause increase or decrease in the number of electrons flowing from the cathode, in other words, a rise or fall of current flowing through the tube. As effects are weaker than with Selenium-cells valve amplification is more necessary in this case, but the Alkali-cell has the advantage, when both electrodes are shielded by earthed metallic rings, of being practically inertialess.

Another class of selenium-cell consists of a platinum electrode and a Selenium electrode in water. A difference of potential is set up by illuminating the selenium electrode. In that it furnishes electromotive force this type is more truly a " cell " in the popular acceptation of the word than the better known Selenium-cell of Bidwell, described above, or that of Siemens. The e.m.f. of this type is, however, so low that the type can only be considered in conjunction with stepping-up by valves. The same can be said of a fourth class of cell, viz. that in which light effects changes in the dielectric constants. Or, if such materials are used in making condensers we can use such a condenser, which changes its capacity according to the intensity of the light to which it is subjected, instead of a light sensitive cell.

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The Requirements of Picture Telegraphy.

(i) The picture must be capable of being broken up into small fragments. This applies to all methods of picture-telegraphy, indirect as well as direct. The fragments are generally not larger than 1 sq. millimetre. We will call them the picture-elements. It is easiest when the whole picture is composed of minute parallel lines, so that the picture stands out only by reason of the different shading of these lines throughout their length. Or, the picture may be composed of parallel rows of minute dots, graduated in shade, or even omitted where parts of the picture are white.

Or the picture may consist of a number of areas of different size and shape and differently shaded, thus bringing out the design, as in a photograph. In this case the Relief method (described below) has to be used.

(ii) There must be a means of tracing off the picture, *i.e.*, something which can touch off in succession the whole of the picture elements which go to make up the picture. This tracer-off is either mechanical—a metallic pencil—or optical—a ray of light.

(iii) There must be a means of converting the optical values of the original picture into electrical values. This is usually done by a light-sensitive cell.

(iv) There must be a means of conveying these electrical values to their destination. This may be a line, in which case they travel as current values, or it may be a transmitter of Hertzian waves, in which case they travel as modulations of a carrier-wave.

(v) There must be a means of converting electrical values at the receiving station back into optical values. This is done by a light-sensitive cell.

(vi) There must be a means of building up the picture again element by element.

The Method of Light-Sensitive Cells.

The general principle has already been indicated, viz.: that the picture to be sent must be capable of being broken up into a large number of small parts, and that a light-sensitive cell measures the mean degree of brightness of each picture element and causes changes in the strength of the line-current to correspond with the changes of the brightness-values. These varying current-strengths are either led to line and so to the receiver, where they are utilized for building up a new picture, or they serve the same purpose by being led to the grid of a transmitting-valve.

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For requirement (ii), the tracing off of the picture, there are with light-sensitive cells two possibilities :—

(1) In the case of a photographic positive or other picture only the degree of brightness of each picture element due to the light diffused from the picture itself is at our disposal, from whatever source the light originally comes.

(2) In the case of a transparent photograph or other picture, *e.g.*, a film, one can work with far greater light-intensities, since a bright artificial light can be concentrated upon each picture element in turn and allowed to fall upon the light sensitive cell after passing through the picture.

When a choice is possible method (2) is much to be preferred, and in Korn's application of this method (patented in 1902) the photograph at the sending station, as a transparent film, is wrapped upon a glass cylinder, which is capable of movement in the direction of its axis in addition to its rotational movement.

A lamp of bright steady light sends rays through a lens on to a spot on the transparent photograph and thus through the cylinder on to a Selenium-cell within the cylinder. The rotation of the cylinder and its regular lateral motion cause every picture element to be traversed in turn, the spot of light tracing off a series of spirals.

With this direct method of picture-telegraphy, as with all other direct methods, the exact correspondence of the touching off of the picture at the sender in order to break it up and the touching off of the paper at the receiver in order to build up the picture again are of the utmost importance.

There are three methods by which such synchronization is achieved :—

(1) Perfect precision of running at each end, and arrangements for simultaneous starting.

(2) Synchronization control is maintained throughout.

(3) Adjustment takes place at the commencement of the operation and a synchronization correction takes place after every revolution at both sender and receiver.

Of these, method (1) is the least certain ; method (2) is the most exact but needs a special circuit to itself if wires are used, or a special wave-length, if wireless is used ; method (3) is not as accurate as method (2), but more economical, and therefore the most used.

The saving by this method is in expense, an extra circuit for synchronization purposes being unnecessary. The loss is in time, but this is very small. The cylinder at the sender has to pause for an instant at the end of each revolution, it is true, but such stoppage is arranged to take place when the touching off ray reaches the fold of the picture where it is held on to the cylinder, at which point the sending of signals would have to cease momentarily in any case.

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When the cylinder at the sender stops, a synchronization current goes out to line. The cylinder at the receiver is set to revolve very slightly faster than that at the sender. It also stops on the completion of each revolution. When the synchronization current arrives it starts again.

The all-important question of synchronization having been arranged for, there is a choice of existing or proposed solutions of the problem of building up the picture at the receiver.

As regards requirement (v), viz.: the reception side:—the first receivers were concerned only with black and white reception, and the matter was comparatively simple, since black or white could be arranged to correspond respectively with current or no current. According as the tracing ray at the sender fell upon a white or black picture element a current was sent to line or not. At the receiver a sheet of paper treated with a solution of potassium iodide was laid upon a zinc plate and a platinum pencil was made to traverse it in the same way as the spot of light was touching off the original picture. The platinum pencil and zinc plate were shunted with a local battery and a resistance, the latter being so adjusted as to permit the local battery to send a current through the platinum pencil and zinc plate when no line-current was arriving. Under these circumstances the paper under the pencil-point was coloured by the passage of the current from the local battery. When line-current arrived the local current at the receiver was checked, no current passed through the platinum pencil and zinc plate, and the pencil ceased to mark the paper. A positive at the sender thus became a negative at the receiver. In this case though selenium was used, the important power it confers of causing graduated signals was not utilized.

Generally, the picture current from the sender is amplified by valves on reception and then flows through the windings of two powerful magnets, between which a small mirror is suspended on the wire of an Einthoven galvanometer. Upon this small mirror impinges a light-ray emanating from a powerful point of light, and is thrown by the mirror into the opening of a sort of photographic camera. According to the strength of the incoming picture-current the mirror is turned more or less out of its position of rest. Thus, owing to varying current-strengths the light-ray from the mirror moves backwards and forwards between the two edges of the opening. In the interior of the camera, opposite the opening, is a light-filter, a glass prism, which, entirely impermeable to light at its base, increases in permeability gradually from opacity to perfect transparency at its apex. Increased current-strength, corresponding to greater light-value of the original picture, causes a greater movement of the mirror. If the differences in transparency of the light-filter are suitably chosen, the latter will permit as much of the light

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coming from the small mirror to pass as corresponds exactly to the brightness-values of the original. That is, optical values having been converted into electrical values are now changed back into optical values. The rays coming from the light-filter are collected by a lens before passing through a small opening at the end of the camera into a light-proof box, which contains the receiving-cylinder carrying light-sensitive paper. When sending-cylinder and receiving-cylinder move in synchrony a copy of the original picture on the former is now drawn on the latter by the light-ray from the mirror, element by element.

This is how Bélin works, who carried out successful trials of picture telegraphy recently (April, 1926), between Vienna and Paris, with the aid of the Vienna Broadcasting station.

It was, however, Korn in 1906 who first used the reflecting galvanometer for this purpose, and uses it still, although he appears to have replaced the mirror by a small triangular aluminium shutter, which, when no current is passing, throws a complete shadow over the opening to the light-proof box containing the receiving-cylinder. As the current increases the shutter turns more and more, permitting more and more light to enter, up to a maximum when it throws no shadow.

THE RELIEF METHOD.

The Relief Method resembles the method of light-sensitive cells in that it leads up to line-currents corresponding in strength to the varying degrees of brightness touched off. It differs from the method of light-sensitive cells in the means of touching off, viz.: mechanical instead of optical. The Relief Method is thus only a different method of breaking up and sending the picture, and applies to the sender end and not to reception.

Touching off mechanically is based upon the possibility of preparing photographs in relief, such relief corresponding exactly in height at every part of the picture to the degree of brightness of the part. A flat relief is prepared either by using a special silver bromide paper, which swells up in water corresponding to the degree of brightness, being more or less steeped in water, or by utilizing the properties of chrome gelatine, which under the influence of light becomes insoluble in water. When a photograph is printed on a layer of chrome gelatine and then washed, the bright portions of the print remain, while those which are dark are partly or entirely washed away, depending on their degree of darkness. If the chrome gelatine layer is of appreciable thickness it will be washed away, according to the darkness of each portion of the photograph printed on it, to an extent which is appreciable by a mechanical toucher off, *i.e.*, a metal pencil. The photograph is then applied to the sending cylinder and hardened with formalin before use. The

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sending cylinder is traversed by the metallic pencil in spiral lines, similar to the movement of the sending cylinder under the light-ray of the light-sensitive cell method. By means of a lever the pencil's vertical movements according to the height of the relief increase or decrease the resistance in circuit, so that, corresponding to the brightness of the picture, currents of varying strengths arrive at the receiver.

Reliefs must be extremely accurate, or no great speed can be attained, and that is the chief drawback of the system. As against the light-sensitive cell method it was formerly urged that this drawback was outweighed by the greater currents obtained by mechanical touching off. This is no longer the case, since amplification has come to assist the light-sensitive cell method. Less inertia was also claimed for the Relief method, but this only applies to the use of Selenium-cells, and not of Alkali-cells. In the latter, as already stated, inertia is almost entirely absent and for the use of the former Korn has devised an inertia-compensator. It appears likely, therefore, that the light-sensitive cell method will gain the day over the Relief method. Bélin, however, who abandoned selenium in 1907, has applied the Relief method to wireless and his recent trials between Vienna and Paris were by wireless and the Relief method.

The Telautographic Method.

This is the method of the old copying telegraphs of Bain and Bakewell—metallic pencils are made to describe a series of parallel lines on metal plates at sender and receiver. The pencils are joined by line, and are earthed through their respective plates. The battery at the sender sends a current to line under normal circumstances, and this causes the pencil at the receiver to make a blue line upon paper which has become conductive by treatment with KCN. When the pencil at the sender comes to a spot on the plate which has been written upon with non-conductive ink the circuit is broken and the pencil at the receiver, continuing on its way, ceases to register until the current comes on again. At the conclusion of the operation the paper at the receiver will show a series of fine blue lines parallel to one another and very close together, interrupted in such a way as to show a fac-simile in white of the hand-writing at the sender.

Bain's patent, which covered the foregoing, dates back to 1843. Bain and Bakewell both abandoned the flat plates, on which the pencils work, in favour of revolving cylinders. The hand-writing at the sender was not done on the metallic cylinder but on a thin sheet of tin-foil, which was then wrapped round it. The electrical principle has remained unchanged. Synchronization was achieved by means of a straight line drawn parallel to the writing. If this line appeared broken the speed of the receiving cylinder had to be

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adjusted so as to make it straight again. Such a method of synchronization was inadequate for quick working and Caselli introduced automatic synchronization, with the aid of which he was able to get up to 900 words an hour, but what spoilt his success in his trials of 1863, was the high capacity in those days of the long lines he used, *e.g.*, from Paris to Marseilles.

Bonelli first increased the number of pencils using five at each end.

If, as Korn thinks, it is possible to use five different high-frequency carrier waves on the same line, then Bonelli's method, using five pairs of pencils, may give Telautography a future by means of wired wireless. Besides electro-chemical reception of the Telautographic method, electro-mechanical reception has been tried with success, but owing to lack of speed, neither of these could give Telautography a permanent place of public utility. This desideratum remained to be supplied by photographic reception.

PHOTOGRAPHIC RECEPTION OF TELAUTOGRAPHY.

Considering that electro-chemical and electro-mechanical receivers give immediately visible results it might well be doubted if photographic receivers, necessitating loss of time in developing and fixing, would prove superior.

The time thus lost has to be gained by extra transmission speed. Even then we have a human element to deal with, in that the telegraph staff have a natural objection to a form of reception producing results not immediately visible. Inasmuch as Telautography can only be brought to practical speeds by photographic reception, the remedies are :—

(1) To reduce the time taken in developing and fixing. This has been done with success.

(2) To give the operator a second and visible picture, not necessarily showing such detail as the photographic picture, but sufficient to assist control.

The speed of reproduction in copying telegraphy is all important, and this for a simple reason. Copying telegraphy cannot afford to be more than a little slower than high speed telegraphy, or running expenses will outweigh the advantages of exact reproduction. While in telegraphy a single letter can be telegraphed by, on an average, five telegraphic signs, a much larger number is necessary per letter in telautography, depending upon the degree of accuracy required. Generally it should be sufficient to reckon 10 to 20 picture lines to each line of hand-writing, and registration is required of every stroke, down to a thickness of $\frac{1}{4}$ mm., *i.e.*, there must be a telegraphic signal every $\frac{1}{4}$ mm. of stroke, passing over letters averaging, say, $2\frac{1}{2}$ mm. broad, and passing over them 10 to 20 times before

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the letter is complete. Allowing for $\frac{1}{4}$ mm. interval between strokes, it will be necessary to register

$$2\frac{1}{2} \div \frac{1}{4} \times 20 \times \frac{1}{2} = 100 \text{ signs for each letter.}$$

A transmission speed of 1,000 signs a second (or 10 letters a second according to the data of the case just assumed) has been reached by telautography, over wires and with photographic reception, but this must be looked upon as a maximum, not because the apparatus is incapable of higher performances, but because Telautography is primarily required for long-distance working, and the high capacity of long lines prevents a further increase. Against this performance of 10 letters a second by Telautography, high speed telegraphy can do 10 to 20 letters a second, and may well in the near future attain to 30. If we are thus forced to admit that the speed of Telautography must remain inferior to the speed of high speed telegraphy, Telautography can only hold a place in the field by the loss of time it entails being balanced by the advantages of fac-simile reproduction.

All this applies to matter with which ordinary telegraphy can deal. It does not apply to the transmission of portraits or of finger prints for police purposes, or of photographs for newspapers.

Such photographs have to be re-drawn first in black and white. At the receiver they are reproduced as negatives on a photographic film wrapped on a revolving cylinder inside a dark cabinet. A small 6-volt 80 candle-power lamp throws a ray through a lens on to a fine metallic ribbon stretched between the poles of an electro-magnet, and when no line-current arrives the shadow of the ribbon is thrown upon the opening to the cabinet. When line-current arrives the metal ribbon is pulled out of position and the lamp throws its light into the cabinet, *i.e.*, on to the photographic film. For long distance working it is better to produce a negative at the receiver, as just described, but in the laboratory it is just as easy to arrange for the opposite, *i.e.*, for the line-current to cut off the light from the camera, and for no current to admit the light. A positive is thus produced, since the interruption of the line-current means that at the sender the tracer is passing over a line of the picture.

Korn, Jenkins and others use this method of photographic reception, but there is also another method, which is based upon Kerr's discovery that when sulphur di-oxide is used as the dielectric of a condenser and the latter is highly charged, a beam of polarized light passing through the sulphur di-oxide is doubly refracted. It is easy to use this phenomenon for darkening or lighting up the reception film, instead of the electro-mechanical method of pulling aside the obstructing ribbon, and there is also no inertia to reckon with, but all advantages as regards strength of light available for reception lie with the mechanical method.

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WIRELESS PICTURE-TELEGRAPHY.

(1) TELAUTOGRAPHIC METHOD.

Even as far back as the days of the Coherer, there were many proposals for wireless to take the place of wires in telautography, since the transmission of black and white (hand-writing and drawings) *i.e.*, of signal or no signal, leaving out all matters of degree or intensity, presented no very great difficulties to wireless. The method of telautographic transmission by wires already described could be modified as follows :—the touching off pencil at the sender to be included in circuit with the source of H.T. and the primary of an induction coil, in circuit with the secondary of which is a spark gap. The pencil would thus permit wave radiation while travelling normally over the picture, and the waves would cease to be radiated whenever the pencil was passing over a place which had been written upon with non-conducting ink. A less primitive method was to govern radiation by means of a relay : but owing to sparking, the cut-out of the relay-arm had to be made comparatively large, and so it was impossible to attain a good speed of transmission. Another disadvantage was the loss of time in bringing the coherer back to its normal state of readiness for reception. As no great speed was attainable, electro-mechanical reproduction satisfied all requirements and photography for this purpose did not need to be considered. Thorne Baker, in 1910, increased the speed by substituting for the coherer a Marconi's magnetic detector, and by introducing a very sensitive ribbon galvanometer, operating a Korn's photographic receiver, as just described under "Telautography."

Up to the war, wireless telautography results continued mostly unsatisfactory, and even when, during the war, the introduction of the valve-amplifier had given very real increases of current at the receiver, the use of the touching off relay at the sender made transmission speed slow.

Towards the end of the war, German G.H.Q. demanded simple wireless telautography sets for transmitting and reproducing sketches made by aeroplane observers, and sets were hurriedly provided both by Korn and by Siemens and Halske with photographic receivers as above, and by Dieckmann with visible reception. All these sets suffered from too slow transmission speed, and, owing to the electro-mechanical relay in the sender, could not get above 60 signs per second, so that in the time permissible, at most 5 minutes, only pictures of the simplest character could be reproduced, and only up to a size of $2\frac{1}{2}'' \times 4''$.

The simplicity of the change from working telautography over wires to working it by wireless does not extend to the arrangements for synchronization. This is a more complicated matter. For

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synchronization when working over wires all that is necessary is to send a current-impulse in the opposite direction to the line-currents. The nearest analogy with wireless would be to send a synchronization signal on a separate wave length, but this introduces an unwelcome complication. Korn does it as follows :—At the end of each line he has a pause of, say, 1/10th the time of a revolution of the cylinder. During this pause no waves are sent out, and the time serves for the preparation of the synchronization signal ; the circuit at the receiver for the release of the synchronization magnet being automatically interrupted during this time by means of a relay, adjusted to work only when a longer pause comes, and not for the short interruptions of the waves, which occur when the pencil passes over hand-writing, etc. After the pause the first incoming wave of the correct wave-length releases the synchronization-magnet. A delay action relay for this purpose may be either on the hot wire principle, acting when the wire has sufficiently expanded, or it may depend for its action upon a Selenium-cell selected as having the requisite degree of inertia.

We have seen that up to the end of the war wireless telautography was hardly meeting requirements. The first condition for increasing its transmission speed was to get rid of the electro-mechanical touching off relay in the sender. Important as this was for telautography by wires, it was much more so when working by wireless, since the relay in the sender always worked with considerable sparking and on this account could not be got up to more than 100 signals a second. Since the war this fundamental condition of progress has been fulfilled by the valve-relay. The principle of this is well known, viz.: that in the triode valve the current produced between cathode and anode by a suitable high tension supply can be altered within wide limits by quite small changes of the potential of the third electrode, the grid. One is able thus to dispense with the aid of the electro-mechanical relay, and to send out the desired impulses by means of the valve-relay, and this without in any way noticeable sparking when the pencil passes from a conducting spot to a non-conducting spot on the sending cylinder. The earliest and simplest idea was to use the valve itself as a transmitter, and this is still done in laboratory trials where transmission energy is low ; but wireless picture-telegraphy at a distance is obliged to use high power in order that reception may not be unduly affected by extraneous signals and disturbances. It is, therefore, not practicable to go from the telautographic sender direct to the grid of a transmitter valve, but the oscillating potential delivered by the telautographic sender is first applied to the grid of a modulating-valve which controls the transmitter. This is the method which underlies all present wireless telautography transmitters. Korn has modified it to the extent of introducing in the

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oscillating circuit of the transmitter a capacity, in parallel with the modulating-valve, which alters the oscillation constants according to whether changes of potential are being applied to the grid or not, and thus mistunes the wave, permitting radiation to continue on a different wave-length when no signal is going out.

At the receiver, now that transmission speed is no longer limited by the electro-mechanical relay at the sender, which alone made electro-mechanical or electro-chemical reception adequate, photographic reception is naturally adopted, the method employed being that of the ribbon galvanometer (described above), or of the reflecting galvanometer, or of the Kerr-cell.

As regards amplification at the receiver which must be considerable, especially for great distances, there is the same limitation as regards working over lines: no transformers are permissible. All low frequency amplification must be done by resistance amplifiers. In general, comparing telautography over wires with telautography by wireless, up to the present the same speeds have been obtained by the two methods, for hand-writing, for drawings and for photographs. As the question is economic, greater speed, which reduces expense, is essential. The equality now existing as regards speed is not likely to continue, since the capacity effects of long lines, even though reduced by " loading," will prevent telautography on land line and cable from gaining any material increase of speed, whereas wireless telautography suffers from no similar incapacity.

(2) The Method of Light-Sensitive Cells and the Relief Method.

Essentially greater difficulties lie in the way of the wireless transmission of pictures by the method of light-sensitive cells and by the relief method. While in the transmission of pictures over wires greater or smaller currents go to line in correct proportion corresponding to the different brightnesses touched off, there is for such transmission by wireless no analogous method possible except that of sending out waves of greater or less energy to correspond with the brightness of the picture elements. The actual sending by wireless of greater or less amounts of energy correctly stepped presents little difficulty, but it is very difficult to receive them. Once outside the laboratory, even over short distances, anomalies appear which have yet to be got rid of. The same thing occurs in broadcasting, where although even over great distances, everything which depends upon frequency, like the tone-sequence and quality, is well reproduced, quite peculiar aberrations occur in tone-strength. Disturbing as these variations may be in broadcasting, in picture transmission, where everything depends on the correct re-production of the degrees of brightness, they are vital. These anomalies, which are not only due to atmospherics and extra-

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neous signals, will have to be thoroughly studied. Apart from this, there is much analogy between the method of light-sensitive cells by wireless and wireless telautography.

It appears to be easiest to produce different potentials by differing degrees of illumination of a Selenium, or other light-sensitive, cell, and to apply these to the grid of a transmitting-valve. The wireless transmitter thus radiates waves of differing energy corresponding in their gradations to the degrees of brightness of the original picture. A sender for the light-sensitive cell method, as used by Korn and already described, is therefore suitable. Similarly at the receiver it is best to work photographically, using the ribbon galvanometer, oscillograph or Kerr-cell, exactly as when working over wires.

For synchronization the same arrangements will serve as when working wireless telautography.

As Korn does in wireless telautography, it is best to interpolate a modulating-valve governing a continuous-wave transmitter, instead of applying the differing potentials provided by means of the light-sensitive cells direct to the grid of a transmitting-valve.

The wireless transmission of pictures by the method of light-sensitive cells may take some such form as that just described, provided the reception difficulties alluded to above can be overcome. This necessary condition has still to be faced, since up to now long distance picture transmission by wireless and light-sensitive cells has been only a partial success. Such success as has been achieved by Marconi's and the Radio Corporation between England and the U.S.A. is possibly to be attributed to :—

(1) A low transmission speed—as evidenced by the use of the lever-arm writer.
(2) Apparently very high power was used.

Hard as people are working in the U.S.A., Germany and France, to make wireless-picture telegraphy by the method of light-sensitive cells a success, it appears likely that wireless telautography will become practical first. It is, however, in the former that the most important prospects of the future lie, not only as regards picture-telegraphy proper but regarding its offspring, electrical vision.

Electrical Vision.

Electrical vision is a special case of picture-telegraphy. What makes picture telegraphy possible is that the optical values of the picture elements, having been changed into current values and conveyed as such to the distant station, are there turned back into optical values, and affect one by one a photographic film upon a revolving cylinder until a picture corresponding to the original has been built up element by element.

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From this it is in theory only a step to electrical vision. Break up the image of a desired object placed in front of the apparatus at the sending station into picture elements as before, and reproduce them simultaneously, or practically so, at the receiver, when the impression of the whole object, instead of being made slowly on a prepared film, can be made by diffusion from a screen instantaneously on the eye.

Thus in picture-telegraphy proper the picture produced at the receiving terminal is a permanent one : in electrical vision it is transient.

In picture-telegraphy proper the time of transfer is technically of no importance, and only a factor to be considered from the standpoint of cost. This time has been reduced now so that a picture 5″ × 4″ can be reproduced in from 5 to 7 minutes by more methods than one.

In electrical vision the time of transfer is of essential importance and must not exceed 1/10th of a second. The nature of the picture produced and the time taken in producing it are thus the chief differences between picture-telegraphy proper and electrical vision. They are alike in the methods used and especially in the fact that what they transmit, viz. a picture in the one case and the appearance of persons or objects in the other case, must first be broken up into picture elements for subsequent re-assembly at the receiver.

Electrical vision may be divided into electrical vision proper and the wireless cinema.

The Wireless Cinema, which is a special case of electrical vision, differs from electrical vision proper in that it deals not with objects but with a succession of photographs. As regards the transient images produced by electrical vision, the limit of time of transference permissible is imposed upon us by the retentivity of the retina. Owing to the inertia of the eye any light impression which affects it persists there for about $\frac{1}{8}$th of a second. From this it follows :—

(1) That in electrical vision proper the total time available for re-assembling the whole of the picture elements must be less than $\frac{1}{8}$th of a second, or the appearance of every portion of the picture will not seem to be simultaneous.

(2) That in the wireless cinema, as in the ordinary cinematograph, pictures must pass before the eye at a minimum rate of, say, 10 per second, in order to produce the necessary impression of persistency.

We must now examine the problems which these conclusions involve. The attempts to solve those arising from (1) date from the discovery that by the use of selenium the lighting of a light at one place could bring about electrically the lighting of another light

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at a distant station. They have thus lasted fifty years, always approaching, without arriving at a practical solution. Carolus, however, had an electrical vision apparatus working in his laboratory a year-and-a-half ago, while Voss has shown on his electrical vision apparatus moving pictures of about the size of a visiting card. The following are the data upon which the problem of electrical vision must be considered :—

(1) An object or picture to be made visible by electrical means must be capable of being broken up into elements.

(2) These elements must not be larger than 1 sq. mm. For sharpness of detail they should, however, be smaller.

(3) The whole of the elements which go to make up the picture must be capable of re-assembly at the receiver in less than 1/10th of a second.

Taking for instance the size mentioned, viz. that of a visiting card, say $7\frac{1}{2} \times 4$ cm., there would be 3,000 picture elements, and these must be carried and re-assembled in less than 1/10th of a second. Either wires or Hertzian waves can serve as the carriers of the currents created at the sender from picture-elements. In the one case the picture-current, amplified, is sent by the line wire, in the other case this current is used for the modulation of a carrier-wave, as is the microphone current in radio-telephony. A third case is also possible, in which Hertzian waves are conveyed by wires, so that by choice of suitable frequencies, three or more frequencies can use the same line wire without interference, thus reducing materially the number of circuits required.

The number of signals per second which can be sent over telephone circuits up to any distance possible in England without difficulty, *i.e.*, while maintaining the due proportionality of the varying currents, is 1,000, or at the rate of 100 signals per 1/10th of a second.

It is evident, therefore, that from the standpoint of practicability, not of possibility, line transmission for electrical vision need no longer be considered, since to carry the currents of 3,000 picture elements in 1/10th of a second we should have to provide 30 circuits. For the same reason " wired wireless " may be left out of consideration, since even with as many as four high frequency carrier waves using the same line, we should still need eight telephone pairs. If, however, eight long distance circuits were forthcoming, there is no doubt that some of the leading experts could put up an exhibition of electrical vision over wires. There remains only wireless picture-telegraphy, and this we know is capable of transmitting and reproducing as a fixed picture in five minutes pictures even larger than the one taken as an example. The question is then :—Can wireless picture-telegraphy reproduce in 1/10th of a second a picture consisting of 3,000 elements? It is suggested

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that the answer is an unqualified affirmative, and that for the following reasons :—

(*a*) Bélin has constructed an apparatus which has proved that the eye will take up (and hold for $\frac{1}{8}$th of a second) light impressions of a duration down to 1/400,000th of a second. He says that this is true to such a degree as to indicate that the limit has not yet been reached.
This would permit the whole of the 3,000 picture elements to be touched off in succession, and if this were done in 1/10th of a second, still to produce the impression of simultaneous vision of all parts of the picture.

(*b*) Carolus using the Alkali-cell, depending upon the Hallwachs effect, and without inertia, sent recently in trials from Nauen 250,000 picture elements in 5 seconds, or at the rate of 5,000 elements in 1/10th of a second.

There appears therefore, sufficient reason to state that by the use of the light-sensitive cell and by the application of wireless to picture-telegraphy, and in spite of the reception difficulties indicated above, the problem of electrical vision has been solved. There is no doubt that the practical problem of electrical vision will also be solved, since this is primarily a question of lowering the cost of existing solutions.

Whether uses may be found for electrical vision proper, and if so what uses, it is difficult to say. A leading dramatist of the day has introduced in a play of the future a scene in which a telephone conversation is carried on with a person whose image is visible during the conversation. No one would dare to say that this will not come true. Another case of more obvious utility would be the visual broadcasting of theatrical performances, combined with the acoustical broadcasting of to-day. As regards the special case of electrical vision, the wireless cinema, there is more certainty about its having a place to fill when it arrives. Cinematograph films will be broadcast to wireless amateurs in their homes, as musical programmes are now broadcast. In fact, it is in broadcasting that the hope of electrical vision and the wireless cinema lies, for the expense of providing the necessary apparatus can only be met by dividing it amongst the largest possible number of subscribers.

Sources of Information :—

(*a*) "Die Bild Telegraphie," by Gerhard Fuchs, published by Siemens, Berlin.

(*b*) Several articles by Emo Descovich in the "Neue Freie Presse," Vienna.

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THE CASE FOR THE HORIZONTAL MULTI-CYLINDER INTERNAL COMBUSTION ENGINE.

By CAPTAIN R. M. H. LEWIS, M.C., R.E.

WHEN faced with the problem of choosing a prime mover of the internal combustion type, the prospective buyer has the choice of a horizontal or a vertical engine.

In the small sizes he can usually find an engine to suit his requirements without much difficulty.

When the larger multi-cylinder type of engine is required the average person who has not studied internal combustion engines very deeply will almost certainly be misled into the popular belief that the vertical multi-cylinder engine is the only possible type to install.

It is very unlikely that he will get any information on the subject of the relative merits of vertical and horizontal multi-cylinder design from the ordinary text books.

This article is, therefore, intended to put the case for the horizontal multi-cylinder engine and to criticise the various claims for superiority put forward on behalf of the vertical multi-cylinder engine.

The vertical engine manufacturer started with the great advantage in the first place that he was following in the footsteps of the manufacturer of the vertical high-speed steam engine.

This type certainly had advantages, which cannot be discussed here, over the old type of slow bulky horizontal steam engine for generating purposes.

It is, however, misleading to take the arguments relating to steam design and apply them to internal combustion design. Temperature problems are entirely different and the necessity of easy and quick overhaul and inspection of valves and piston does not apply to the steam engine.

In addition, for obvious reasons, for marine and transport work the horizontal engine is out of the question.

The advantages claimed for the vertical multi-cylinder I.C. engine are :—

(1) Small space occupied. Inexpensive foundations and buildings.

(2) Good balance and absence of vibration.

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(3) Uniformity of torque and small cyclic irregularity.
(4) High speeds suitable for direct coupling to electric generators.
(5) Forced lubrication minimizing the risk of hot bearings.
(6) Less wear on cylinders because owing to their vertical position they have not to support the weight of the pistons.
(7) Low weight per B.H.P.

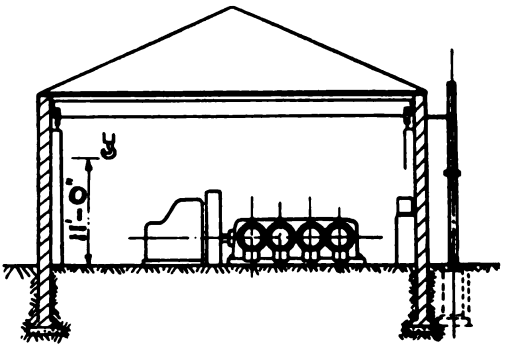

Fig. 1.

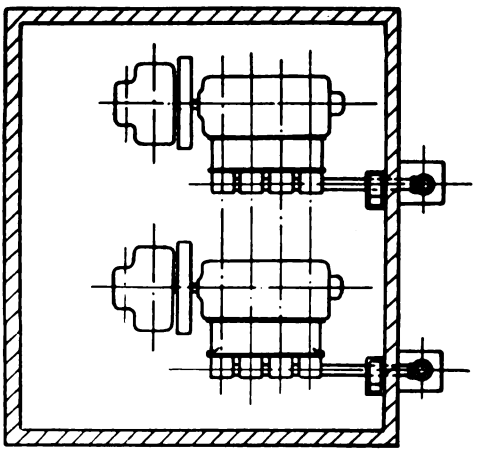

Fig. 2.

To discuss these claims :—

(1) Figs. 1 and 2, reproduced from a pamphlet on the horizontal engine brought out by the Premier Gas Engine Co., show an engine house for two 400 h.p. Premier horizontal engines, and Figs. 3 and 4 show an existing engine house for two open type Diesels of similar output.

In Figs. 3 and 4 the operating platform seems rather unnecessarily elaborate, especially the connecting gangways, which are not usual practice; as the comparison stands, however, the floor

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space in both engine rooms is the same and the percentage of floor space available for dismantling the horizontals is some 13 per cent. greater than that available for dismantling the verticals.

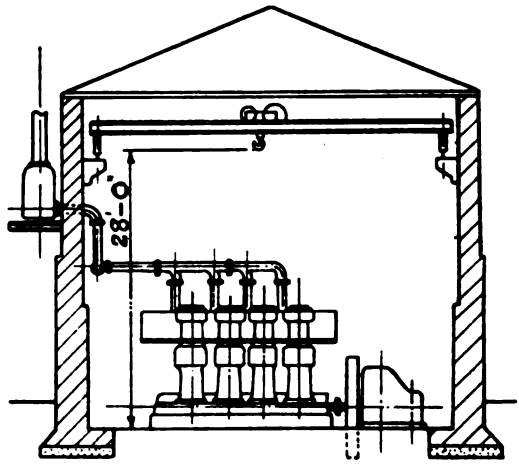

Fig. 3.

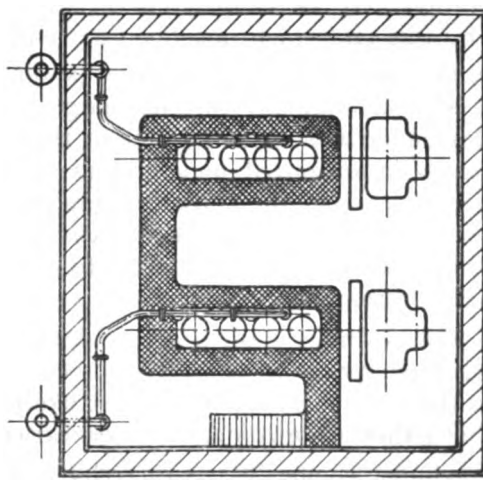

Fig. 4.

As the pistons of the verticals have to be drawn out of the cylinder vertically, the height and, therefore, the cubic capacity of the engine room for the vertical engines must be the greater of the two.

On the other hand, it must be remembered that, especially in military installations and in adding to existing installations, one is not always one's own master as to floor space. The vertical installation could be further compressed if necessary at the expense of ease of dismantling and examination. Also where space is

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limited the closed type of vertical engine occupies less space than the open type illustrated.

The horizontal installation shown is occupying about the minimum floor space desirable.

The question of foundations is very closely bound up with that of vibration, and here a comparison can be made with the old vertical steam engine. The horizontal engine being a slower speed engine than the vertical will, other things being equal, be the heavier. Therefore, the weight of foundations per b.h.p. must necessarily be heavier, too.

The foundation for the horizontal engine must also, owing to the shape of the engine, be slightly more complicated and of a larger area. It does not appear that in itself this is a very grave disadvantage.

On the other hand, owing to the direction of the thrust, the vibration (if any) produced by a horizontal engine is confined to the surface and localised in the engine room.

The foundation of a large vertical engine may give no trouble at all; but, on the other hand, if there happens to be in the subsoil under the foundation a stratum capable of transmitting vibrations, very serious vibration may be caused, not in the engine room, but transmitted by this stratum to neighbouring buildings.

As an example, the case of one large London power station may be quoted. This station originally installed large vertical power units (steam). No undue vibration was felt in the engine room, but the vibration was transmitted underground to neighbouring dwellings, and so serious was the nuisance resulting that, after spending a large sum of money in unsuccessful attempts to insulate the foundations, the company eventually had to scrap the entire plant and substitute turbines.

(2) Balance in multi-cylinder design, given identical conditions *re* number of cylinders, speed, weight of reciprocating parts and total weight, also the same ratio of length of stroke to connecting rods, is identical in either a horizontal or a vertical engine.

Taking a four cylinder engine, it is easily shown that primary balance as regards reactionary vibration and that caused by the displacement of the centre of gravity due to the piston movement is perfect. The disturbing force of the secondary vibration, due to the angularity of the connecting rod, remains, however, and increases as the square of the speed.

The slower the engine speed, therefore, the less should be this disturbing force.

It would, therefore, appear that the horizontal engine with its slower speed should be, if anything, at a slight advantage over the vertical in this respect.

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(3) Uniformity of torque and low cyclic irregularity. These factors depend chiefly on the weight of the flywheel and the number of impulses per revolution. The horizontal engine should, therefore, be at no disadvantage in this respect, and, in fact, a sufficiently good cyclic irregularity can be obtained to drive alternators in parallel, which is the severest test an engine is likely to be called upon to undergo.

(4) High speeds suitable for direct coupling to electric generators. Given good balance there does not appear to be any reason why the horizontal engine should not be run at as high a speed as the vertical. From the point of view of longevity of the engine, however, high speeds are to be avoided, even at the expense of a slightly larger generator. Horizontal engines are run at slower speeds than the vertical type.

(5) Forced lubrication minimizing the risk of hot bearings. There is much to be said for and against forced lubrication, which is very largely, though not universally, used for vertical engines, *e.g.*, many Diesel engines have plain ring oiled main bearings and banjo lubricated big ends.

Forced lubrication has not got the merit of simplicity, and a claim for superior reliability over ring oil and banjo ring lubrication is very open to question.

It is true that forced lubrication allows of higher bearing pressures owing to the greater rate of dissipation of heat, but on the other hand, the crankshaft usually has to be of such diameter for rigidity and absence of whip that high bearing pressures are not necessary. As for the little end bearing no trouble is usually experienced with the ordinary drip feed or splash, although this is the most heavily loaded bearing in any engine.

(6) Less wear on cylinders, because owing to their vertical position they have not to support the weight of the piston.

In a properly lubricated modern engine there is not much evidence to support this contention. In the horizontal engine the pressure of the piston against the cylinder wall is made up of two forces :—

(*a*) The component of the gas pressure transmitted by the connection rod, which acts at right angles to the cylinder axis.

(*b*) The weight of the piston and portion of the connecting rod, which is only some 8 per cent. of (*a*).

In the most common type of vertical engine, *i.e.*, the trunk piston type, the pressure of the piston on the cylinder walls is due to the component of the pressure transmitted by the connecting rod, which acts at right angles to the cylinder axis. This pressure is slightly greater than (*a*) before mentioned, as the connecting rod is now transmitting not only the pressure due to the explosion, but also that due to the weight of the piston.

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The nett difference in side pressure due to gas pressure and piston weight in horizontal and vertical design is, therefore, not very material.

There are three other factors which have far more bearing on cylinder wear than the above, and all three favour the horizontal engine.

(*a*) High pressures and, therefore, heavy wear is often caused by gas pressure inside the rings, forcing them out against the cylinder walls, the gas entering at the ring joint.

Fig. 5 shows a cross section of a horizontal engine, from which it will be seen that the ring joints are in the bottom half of the cylinder where the rings are home in their grooves. There is, therefore, little chance of the gas leaking in behind the ring at the joint.

(*b*) Fig. 5 also shows that the lubricating oil tends to flow towards the bottom of the liner, which is taking the side thrust, thus always ensuring a good oil film there and helping to seal the ring joints. This obviously cannot be the case in a vertical cylinder, where the piston ring joints are left either to arrange themselves or spaced equally around the circumference.

(*c*) The cold water coming in round the bottom of the cylinder of the horizontal engine cools the most heavily-loaded portion very effectively, and ensures that the lubricating oil at that portion retains its viscosity.

In the vertical engine the cooling water is hottest near the top of the cylinder, where the temperature conditions are most severe and the gas pressure trying to force its way under the rings is highest.

The question of piston slap in a worn liner must not be overlooked. Piston slap is bound to be detrimental to lubrication. As an illustration of this fact, take two face plates, put a patch of oil on one or both and smash them together—don't try it, however, unless suitably clad.

In the horizontal engine the change from upward to downward pressure on the cylinder walls occurs generally well before dead centre. In the vertical engine the change occurs during the swing over dead centre, *i.e.*, at the moment of maximum pressure.

The slap and, therefore, the tendency to squeeze out the oil film, must obviously be accentuated in the vertical type.

Thus near the top of the stroke of a vertical engine there is a combination of poor lubrication and possible gas pressure behind the rings, demonstrated by the fact that the greatest wear in the vertical engine liner is nearly always found at the top end.

On the question of weight, it is a little dangerous to generalise. On the face of it, given identical conditions of horse power, efficiency, etc., it would appear that the vertical engine with its higher speed

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n the question of weight, it is a little dangerous to generalise. the face of it, given identical conditions of horse power, efficiency, ., it would appear that the vertical engine with its higher speed

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must have an advantage in overall weight over the horizontal, if the same factor of safety is employed.

Figures in the possession of the writer for one well-known and reliable make of horizontal engine, however, compare favourably with those of vertical engines with which it is competing.

In addition, these figures show that the larger the engine (and, therefore, the more important the weight factor) the better do the horizontal weights compare with those of the vertical.

So much for the claims of the vertical multi-cylinder engine to superiority over the horizontal.

A few points may now be mentioned in which the horizontal multi-cylinder engine has undisputed advantages over the vertical.

(1) Compare Fig. 6, a vertical engine cylinder head, with Fig. 7, a horizontal engine cylinder head of the same type of engine.

Among the failures in service necessitating the longest stoppages, perhaps the most common in I.C. engines are cracking of castings exposed to the heat of combustion or exhaust. These arise from excessive temperatures and sharp temperature gradients in parts of the casting, and are aggravated by the use of hard or dirty water, which causes non-conducting deposits to be formed on the cooling surfaces, and frequently blocks narrow water passages entirely.

Fig. 6 shows very clearly the constricted nature of the water passages in a typical vertical engine cylinder, and the difficulty of getting at them for cleaning purposes.

Furthermore, the proper circulation of water at very hot portions (*e.g.*, between the fuel and exhaust valves of a Diesel) is difficult to arrange, and the heat has very often a long passage to the water-cooled surfaces.

Moreover, the cooling water for the vertical cylinder head sometimes passes through the cylinder water jacket first, and thus arrives at the hottest portion of the engine nearer the temperature at which it deposits matter in solution.

Fig. 7 shows the simpler nature of the horizontal combustion head, the large and straightforward water spaces and the big inspection and cleaning doors that can be arranged.

It will be noticed that the cooling water enters at the bottom near the hottest portion of the combustion head (*i.e.*, the exhaust valve) and, heated, rises towards the cooler inlet valve and the outlet.

Temperatures, therefore, over the combustion head are more uniform, and the tendency for internal stresses, and, therefore, cracking of the cylinder head, is less.

(2) In the horizontal engine everything is, so to speak, on the ground floor. The attendant is, therefore, more likely to exercise proper supervision of his engine.

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(3) A common cause of stoppages is a heated bearing. In a horizontal engine an experienced attendant can always tell by inspection when a bearing is starting to run hot, and take steps to increase the oil supply at once without a shut down.

In the vertical engine the first warning of a hot bearing is usually the engine refusing its load.

(4) A comparison of Figs 8 and 9 and 10 and 11 show two more great advantages in accessibility of the horizontal multi-cylinder engine.

(5) Fig. 12 shows a very good arrangement for partially removing the sludge, which always contaminates the lubricating oil in high compression oil engines.

Such an arrangement is not practicable in the vertical engine.

(6) In a properly designed horizontal engine valve inspection and replacement is quicker and simpler than in the vertical engine—an important matter in high compression engines.

It is hoped that this article will have proved that to the many claims of the vertical multi-cylinder engines the horizontal multi-cylinder engine can make an adequate reply, and add a few claims on its own account.

The subject of first cost is again a dangerous one to generalise on, unless figures for a large number of makes representative of both types of engine are averaged.

On the whole, the horizontal engine is simpler to manufacture, and even combined electrical sets of the horizontal type can compete successfully in first cost with those of the vertical type.

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THE DEFENCE OF AOULAI.

By LIEUT. H. B. HARRISON, R.E.

When in April, 1925, Abd el Krim threw off the mask and attacked the French zone he employed the same tactics as had brought him success previously against the Spaniards, namely, the infiltration of bodies of troops between the defensive posts along the frontier, to stir up the country in the rear and eventually to surround and storm the posts in detail.

Aoulai found itself thus surrounded towards the end of April, and successfully repulsed five fierce assaults before being relieved on May 15th. The post appears to have been of the usual rectangular pattern, about twenty yards by fifty yards, with one main gateway, mud brick walls with bastions at the corners.

The siege is of interest as representing the resistance offered by a post not designed to withstand shell fire, when suddenly confronted by an enemy possessing field artillery. The situation as presented to the French captain is one that may quite conceivably have to be faced at any time by those in charge of our many frontier posts, and it is interesting to note the measures adopted at Aoulai and their subsequent results.

The chief lesson of the siege is that, to oppose shell fire, posts must have prepared beforehand a complete trench system, both outside and inside the walls, transforming the position into the strong point of field warfare. Then, given sufficient supplies of water, food, bombs, and ammunition, and in the hands of resolute defenders, a post should be able to hold out until the arrival of the inevitable relief column.

Composition of the Post.—On May 1st the garrison consisted of the following:

Europeans:—1 Captain, 1 Subaltern, 4 N.C.O's and 3 men.
Natives:—38 Senegalese.

There were four machine guns in the post and one light gun, which, however, had previously been damaged and was useless.

The Riffs considered the capture of the post most important for the following reasons:—

(1) Built on the high ground which forms a buttress between the Kelaa-des-Sless and the disaffected zone, the position is an ideal one from which to operate against the neighbouring posts.

(2) It was the gateway to the road to Fez, where were stationed the French Headquarters of that sector, together with important accumulations of stores of all kinds.

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From the tactical point of view everything favoured the Riffs. The post had no guns; the outlying works were soon captured; and the post itself was overlooked from four dominating points, at distances of fifty, a hundred and fifty, four hundred, and nine hundred yards from the walls.

The First Attack, May 1st.—The attack opened by rifle fire accompanied by a few shells, one of which wrecked the cookhouse.

At 8 a.m. the lookout signalled the approach of about one hundred Riffs half a mile north of a neighbouring blockhouse, which was being closely invested.

The O.C. post at once ordered his subaltern to proceed with one N.C.O. and 6 men to a ridge about 150 yards S.E. of the post and

(1) Dislodge the snipers firing on the post.
(2) Prevent the advance of the Riffs.
(3) Assist with their fire the garrison of the blockhouse.

Carrying out his mission with complete success, the subaltern succeeded in driving off the enemy snipers, while the N.C.O. surprised several local tribesmen hiding among the olive trees between the post and the blockhouse. The advancing Riffs took cover and opened fire from a ravine some distance away.

About 2 p.m. the subaltern reported small parties of the enemy working round his right flank, and was ordered to withdraw into the post; the withdrawal cost two men wounded.

At 5 p.m. the enemy again tried to approach, but was held off by picked riflemen.

From 8 a.m. till noon every available man had been hard at work digging trenches which, elaborated later, were to save the garrison from the effects of the enemy's shells.

Defensive Works Carried Out.—Up to May 5th the enemy made no actual assault, but snipers hidden in positions around the post kept up an accurate and harassing fire on the men employed on the defensive works.

The works completed up to the 5th were:—

(*a*) Outside the post: 3 look-out posts, 1 covered post, 1 communication trench, 1 m.g. emplacement, 1 line of shell slits, all in the dead ground to the N.E. of the post.
(*b*) Inside the post: 1 redoubt inside the supply store, 2 trenches with overhead cover, 1 central communication trench, 2 dug-outs, 1 barbed wire entanglement round the redoubt, 2 sunken munition dumps, 1 water hole, loopholes in the walls to cope with the enemy snipers.

For the 6th, the O.C. Post ordered a well-earned day of rest, and told off the N.C.O's. to the various defensive sectors for which they were to be responsible.

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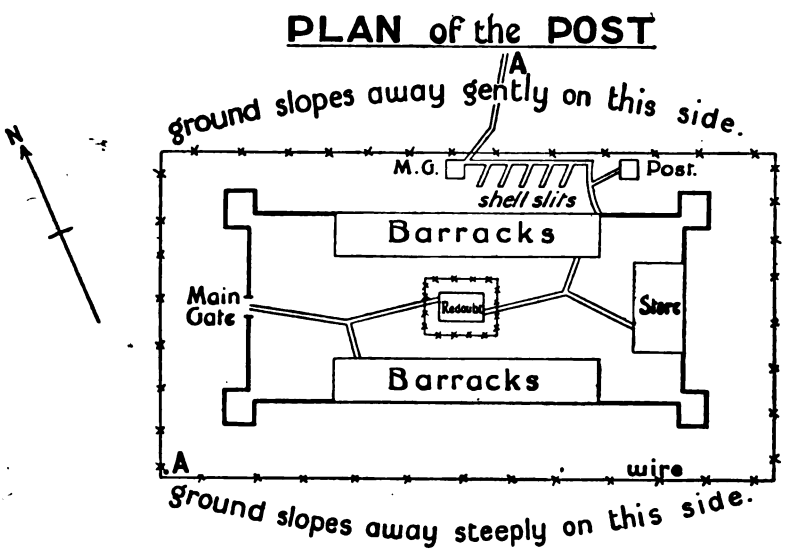

The water tower was situated at approximately sixty yards northwards from the main gate.
Look-out posts at A A: the third was close by the water tower.

Plan of Defence.—The defence was allotted as follows:—

Main gateway	..	1 Subaltern and	4 men.
Local reserve ..	..	1 N.C.O.	,, 4 ,,
S.E. bastion ..	..	1 ,,	,, 3 ,,
N.E. bastion ..	..	1 ,,	,, 4 ,,
N.W. bastion	..		4 ,,
S.W. sector ..	..	1 ,,	,, 4 ,,
Redoubt ..	..	1 ,,	,, 2 ,, (wounded)
General Reserve	..	1 Captain	,, 6 ,,
Water Tower	..	1 N.C.O.	,, 4 ,,

Every N.C.O. and man had a definite task allotted to him, and strict orders were given that bombs and grenades were only to be thrown when good targets presented themselves.

Accordingly, by the 6th, the post was ready to resist an attack supported by field artillery.

Second Attack, May 6th.—On the 6th, about a thousand Riffs and tribesmen stormed the blockhouse of Ourtzag after a twelve hours' bombardment.

About 2 p.m. on the same day, elated by their success, the Riffs attacked the east face of Aoulai after an accurate bombardment by a 75 mm. field gun. The attack was supported by bombs and grenades, but was driven off with the loss to the defence of three Europeans and four natives wounded.

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The enemy contented himself on the 7th with subjecting the post to a severe bombardment from two 75 mm. field guns and one of 6 cm.

During the bombardment the defenders took refuge in the shell slits and trenches, and the moral of the Senegalese was not impaired.

On the 8th, about 300 of the enemy were observed approaching in small groups, and during the night of 8th-9th the post was subjected to severe sniping.

Third Attack, May 9th.—At dawn the Riffs were heard coming down from the village, singing as they advanced, and though hidden by the mist, it was clear that they were in strength.

At 7 a.m., three guns opened a fire which lasted for an hour, at the end of which about 80 riflemen and grenadiers made a determined assault on the east flank, firing and throwing grenades as they advanced, and urged on by the encouraging shouts of a group of about 200 villagers in the background. Being driven off with the loss of five men, they tried to work round further to the north, but were again repulsed and forced to retire to their trenches. The defence suffered only one casualty in this action.

It was at this point that aeroplanes arrived to assist the defenders of the post, and they continued to do so until the post was relieved. They helped by bombing the enemy and by supplying the defenders with water and food, ammunition and medical necessities. The water was supplied by dropping lumps of ice.

While the aeroplanes were overhead the Riffs adopted the tactics of ceasing fire altogether, both guns and rifles, and remaining motionless. This made it difficult for the observers to spot their positions.

Fourth Attack, May 10th.—The water tower was fired on by the Riff guns, and collapsed at the sixth shell. Its garrison of 1 N.C.O. and 4 men retired towards the post, but they were all killed or taken prisoner.

At 9 a.m. the Riffs decided on a supreme effort, and after a heavy bombardment, about 200 of them advanced to the assault, the riflemen firing on the loopholes, while the bombers and grenadiers hurled their missiles into the post. The main gate was the most seriously threatened point and for a time the defenders were forced back, the subaltern being wounded. However, the timely arrival of several bombers of the reserve saved the situation and the enemy was forced back, coming, as he retired, under fire from the machine gun in the S.W. bastion. The defence suffered the following casualties: 3 killed, 5 wounded (including the O.C. Post and the subaltern), 4 missing.

At this point the O.C. Post received a communication from

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Headquarters ordering him to evacuate the post by a night sortie, and to retire on Fez, if the enemy's guns were causing him too severe casualties.

This order could not be carried out, firstly because it would have meant abandoning the wounded, and secondly, because the post was being too closely invested.

The moral of the Senegalese still remained high, and on the night of 10th-11th one of them crawled through the wire entanglement and bombed the nearest enemy trenches.

Fifth and Final Attack, May 11th.—Taking advantage of a heavy mist that prevented the aeroplanes from operating, the Riffs attacked again as on the previous day, after a preliminary bombardment by about 20 shells, one of which killed the subaltern.

The attack was launched simultaneously against the west and the east sides of the post, that on the west being carried out by about a hundred villagers, who were at once checked and dispersed by the machine guns on that side. On the east it was a more serious matter, the attack being driven home by about 100 regular Riffs, who succeeded in forcing back the defenders of the main gate. A strong body of the enemy installed themselves close up to the wire entanglement, and despite an accurate fire from the loopholes, began forcing their way through.

At this critical moment an aeroplane came to the rescue, and this, combined with a bombing counter attack by the defenders, forced the enemy to withdraw, leaving 15 casualties on the ground. In this counter attack the last remaining bombs were expended.

This was the last effort of the Riffs, who made no further assault, and contented themselves with bombarding the post.

On the 15th the relief column raised the siege.

Losses of the Defence during the 15 Days Siege.

Europeans: 1 Captain wounded, 1 subaltern killed, 3 N.C.O's wounded, 1 man missing.

Natives: 4 men killed, 6 men missing, 1 N.C.O. and 13 men wounded.

Ammunition Expended by the Defence: S.A.A. 38,000 rounds, bombs 780, grenades 450, Verey Lights 86.

Method of Attacking a Post adopted by the Riffs.—The following sums up the procedure adopted by the Riffs.

The attack consisted of three phases:—

(1) Preliminary Reconnaissance.

(2) Preliminary Bombardment.

(3) The Assault.

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(1) *Preliminary Reconnaissance.*—This consisted of the sending of agents to collect all possible information from the local villagers; the posting of observers to watch the actions and habits of the defenders, and the telling off of snipers whose sole objective was the O.C. Post.

(2) *Preliminary Bombardment.*—The length and severity of this phase depended on the importance of the post to be captured and on the resistance offered by the defence.

It usually began at dawn by a sudden fusillade directed against all points of defence, the loopholes being rendered untenable by fixed rifles or picked marksmen.

A badly organised defence might reply to this by the wholesale throwing of bombs and grenades, which is merely a waste and reduces the number available to assist in repulsing the final assault.

The next step in the second phase was the bringing into play of the artillery. The Riffs possessed a number of 75 mms., some bomb-throwers firing at close range, and a type of small gun, 6 cm. which fired at ranges between 600 and 1,000 yards. The average rate of fire adopted by the Riffs was about 6 rounds an hour which increased just before the assault. Under cover of this fire bombers and grenadiers crept up to the post, flung in their missiles and withdrew again.

(3) *The Assault.*—When the enemy thought that the garrison had been sufficiently reduced in numbers by the preliminary bombardment, and that the defenders' bombs were beginning to run short, the assault was launched. Every available man advanced to the attack supported by bombers and grenadiers.

A well organised defence would have reserved its bombs for this moment.

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THE ARMY "SECURITY" PROBLEM OF THE NEXT GREAT WAR.

By BREVET MAJOR B. C. DENING, M.C., R.E., *p.s.c.*

The problem of "Security" is one which so largely affects the conduct of war, and one which is so rarely discussed or considered in the every day training of the Army for war to-day, that no apology is called for in bringing forward this subject.

What actually is meant by the term "Security," and in what way does it affect the conduct of war?

"Security" is not easy to define. To many it must appear akin to the term "protection," at rest, on the move, etc., but in reality it is entitled to a broader interpretation. Under the heading of "Security" comes any form of activity intended to "secure" an army against enemy action of any description. It implies rather the prevention of information reaching the enemy, which may enable him to act, than the warding off of the actual enemy himself. The "Security Service" is really the converse of the Intelligence Service, and may, perhaps, be described as Defensive Intelligence. An outline of the organisation and employment of the Security Service in France in the Great War may be helpful in explaining the type of problem coming under the heading of "Security," and in showing the importance of "Security" in war.

It will be remembered that in the years of the war 1915, 1916 and 1917, the British Army was continuously employed in France, either in conjunction with Allies or alone, in offensives against the Germans, designed to break the German front and to introduce a war of movement. These offensives cost many lives and met with only a measure of success for the principal reason that they never in those years came as a complete surprise to the enemy. The enemy was always able to obtain information of an impending or actual attack in time to bring up his reserves and to close any breach made in the line. The fact that it was obvious that we were, in all our operations, giving away information to the enemy which could lead to the neutralisation of those very operations, caused the creation in 1918 of a new branch of the Intelligence Section of the General Staff, known as the "Security" Staff.

The "Security" Staff and its work should not be confused with those of the Contre Espionage and Secret Service branches of the Intelligence Service. There always had been in France, prior to 1918, a staff known as "I (b)," which carried out both

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Contre Espionage and Secret Service duties. These duties, however, as the names imply, included respectively only action against suspected persons in allied territories, and action by our agents in enemy territories. The "Security" Service designed in 1918 was intended to cover a different field, to protect our own troops against their own indiscretions. It possessed at no time any great numbers of servants. In fact, its principal personnel consisted, early in 1918, of only 6 officers, a head "Security" Officer at G.H.Q., with subordinate "Security" officers at each of the 5 Army H.Q.'s. In corps and divisions, in fact in any formation, it was hoped that with the watchful activities of the Army "Security" officers to help them, the General Staffs of formations would themselves take in hand the supervision of "Security" measures.

As already mentioned, the duties of the "Security" Service included the taking of all measures necessary to prevent information of any description reaching the enemy. In order to take such measures, it was clearly necessary for the "Security" Staff to possess a very high knowledge of the means by which an Army normally gains information about its opponents. Such means in the last war in France were the Air Force, observation of the enemy from the ground, prisoners and deserters, intercepted telephone and wireless messages, Secret Service and reports in the Press, allied or neutral. It became the task of "Security" officers to see that nothing untoward was exposed to the view of enemy air or ground observers and cameras, that men were given no opportunity of being taken by the enemy prior to important events, that telephones and wireless, etc., were not used carelessly—with possible activities of enemy Secret Service agents and with undesirable reports in the allied or neutral Press, the "Security" officer was not so personally active, for there were already in existence, prior to his creation, respectively the Contre Espionage and Censor Staffs. A glance at the real meaning of the task in front of the "Security" Service will show how immense it was. When it is recollected that every scratch in the ground, whether for a new road, a gun pit, tramway, dump, hospital, trench or even dug-out was plainly discernible upon an air photograph, it can hardly have been easy to devise measures to prevent the enemy "noticing anything" from the air. Similarly any increased work or movement was hard to conceal from accurate and systematic ground observation. And it was difficult to prevent the enemy carrying out a raid on our lines, if he was really determined to gain information, and equally difficult to stop all garrulous telephone and wireless personnel from giving away intelligence.

The following is an example of the type of work carried out by the "Security" Staff in 1918. It was realised quite early in the life of this new service that one means of preventing the enemy

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from obtaining correct information was by putting him off the scent with false information. Prior to the great Franco-British offensive at Amiens on August 8th, 1918, it was found necessary to move the Canadian Corps of four large divisions down from the Ypres front to take part in the attack. The problem of concealing the transfer of so large a force to the front of intended attack was a real one. The problem was studied by the "Security Staff," and the following measures were taken. First, the move of the Corps was postponed till the last possible moment; and then it took place at times when it would escape the observation both of enemy airmen and local inhabitants of doubtful character. Secondly, no preparations were permitted in the zone of attack. The incoming troops were required to bivouac and to make use of the ground as they found it. Thirdly, to prevent the enemy from noticing the departure of the Canadian Corps from Ypres, some Canadian troops left in the front line contrived to give the enemy a Canadian identification just prior to the appearance of the Canadian Corps at Amiens. As a result of these and other similar measures, the battle of August 8th, 1918, came as a complete surprise to the enemy and led to a victory, which Ludendorff himself admits was the beginning of the end, as far as Germany was concerned.

During 1918, not only the British but also the French and German General Staffs realised the necessity of studying "Security' problems. Prior to the great French counter-attack north of Chateau Thierry on July 18th, 1918, the greatest pains were taken to make the attack a surprise. Before the big German offensives of March 21st, April 9th and May 21st, 1918, there was ample evidence of the efforts the Germans were making to prevent information reaching the Allies.

It may be contended that the work necessary to obtain a surprise is merely one of the normal duties of any General Staff, for *F.S.R.* includes "Surprising the enemy" as one of its eight Principles of War. That argument is perfectly correct and every officer, whatever his employment, probably realises the necessity for surprise. Unfortunately, that is not sufficient. In war, as in manœuvres, everyone is so fully occupied, if not actually so overworked, that no one has time or strength left to quietly consider whether anything is being done that might give information to the enemy, or whether anything is being left undone which might deceive him. The regimental officer will naturally rely upon the Staff to do what is necessary.

The Staff, however, has so many immediate and pressing problems that the question of surprise, at the time rather academic looking, is very liable to be placed in the background and subsequently forgotten altogether. If this was the case in position warfare, how much more is it likely in the harassing life of moving operations.

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There is little doubt that a special " Security " Staff is required in future wars to watch over this special subject. This staff could well be small, for one officer per independent formation, such as a Division or Corps in small wars, and Armies in big wars, would suffice. It would be so closely allied to the Intelligence Branch of the General Staff as to be inseparable from it. Yet its officers would require a somewhat different training and outlook from those of the Intelligence Branch proper. The important point to be remembered is that Security officers should *not* be treated merely as extra assistants for ordinary General Staff work, as is very likely to happen under stress, but should be left free to think, to study events and to go about over the whole scene of operations to see that " Security " is not being forgotten.

Is the work of the " Security " officer in the next great war likely to differ from that of 1918? Probably not greatly. As already pointed out, the task of the " Security " Service is one of frustrating the enemy's methods of obtaining Intelligence. Unless sources of Intelligence in the future are likely to be different from those employed in the past, " Security " work cannot alter much. The sources available will be dependent on the type of warfare. Whether warfare in future will differ entirely in type from that of the past is a matter of opinion. If we have stationary warfare, periodically interrupted perhaps, by offensive operations leading to partial movement, there is little reason to suppose that the means of obtaining information, as employed in the last Great War, will change greatly. There will still be aerial observation, the capture of prisoners and documents, the reports of agents, observation from the ground and the various other usual sources of Intelligence. If, as some anticipate, armies are likely to be small and very powerful, possessed of great mobility, it may be that war will not often be stationary, but may revert to the manœuvre type of years gone by, with the difference that armies, and events, will move far more rapidly. If such be the warfare eventually in store for our Army, the task of " Security " officers will again be much the same. The task may be the simpler in that the opposing Intelligence has less time and opportunity to pick up information. Yet it will still be just as necessary to watch over our rapidly moving columns, to see that nothing is done which may give away the intentions of the Commander as it is in the case of stationary entrenched forces. With armies as they are to-day, however, possessed of immense numbers of machine guns, *i.e.*, immense defensive power, and small numbers of tanks, it is fairly safe to assume that for the next few years the stationary type of warfare is likely to prevail.

To perform his duties thoroughly, the " Security " officer requires very great imagination and great knowledge of the every day procedure, staff and regimental, of the force he is serving.

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The necessity for "Security" measures in connection with the use of wireless is pretty generally realised and partially provided for in most armies. It is doubtful whether the same can be said of "Security" against information leaking to the enemy by other means. Particularly is the influence of information obtainable by aircraft not sufficiently considered before operations are undertaken.

In 1914 all the armies, British, French and German, advanced mainly by day. By 1918, for the big attacks, all major movements were carried out by night. In training for war to-day, which do we contemplate? Supposing our main columns continue to march at 15 miles a day, by day, is it conceivable that they can escape observation from the air? There is a school of thought in the Army which argues that you cannot ask troops to operate continuously by night without a decisive loss of morale. The writer begs to differ. There were many units in the winter of 1914-1915 in the Ypres Salient which were forced to operate for weeks on end by night, for the reason that the forward zone was under direct enemy observation, and no communication trenches existed. Prior to the big German offensive of 21st March, 1918, there is documentary evidence to show that certain highly trained German Divisions marched for seven successive nights in the advance to the attack, and assaulted with the greatest success on the morning of the 8th day. These and other events of the last Great War go to prove that, where the reason is quite clear to the troops and when adequate arrangements are made for rest by day, continuous night operations are not impossible. But what is the doctrine on this point to-day?

The many points it is necessary to remember in connection with "Security" work were well known to us at the end of the Great War. Many lessons had been learnt by bitter experience. This knowledge is rapidly slipping away from us, and who can be sure that in a new war in a few years' time most of the lessons will not have to be learnt again?

A general recognition of the necessity for "Security" should permeate the Army and particularly all centres of military study. In peace time it should be the duty of someone to study changing methods of obtaining information and the consequent new measures necessary to prevent such information reaching the enemy. "Security" officers at manœuvres could learn a great deal and reports and lectures from such officers would do much to keep this all-important subject before the military eye. As it is, it is very doubtful if the subject receives a second's thought in the busy life of the average officer to-day.

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NOTES BY A CHIEF ENGINEER DURING THE GREAT WAR OF 1914-1918 (*continued*).

By BRIGADIER-GENERAL W. BAKER BROWN, C.B.

WORK FOR OR WITH THE Q. STAFF.

The work in connection with quartering formed the larger part of our duties.

As soon as war became imminent the D.F.W., Major-General G. Scott-Moncrieff, at once began the preparation of schemes for hutting additional units, the actual work being under the control of Lt.-Col. B. Armstrong, R.E. On the appointment of Lord Kitchener as Secretary of State, he at once stressed the necessity of preparing for a long war and ordered the schemes of hutting to proceed. Further, Kitchener cut through the War Office routine, sent for Scott-Moncrieff as his principal engineer adviser, and gave him personal instructions not only as regards the policy of hutting but regarding details and sites. As General Scott-Moncrieff has given us his own account of how he carried out these instructions, I need not go into details, but I may mention one point as it had some bearing on our later work. When making out his original scheme the D.F.W. had naturally worked out the cost and estimated that a Battalion of Infantry could be hutted for an expenditure of £12 10s. per head of all ranks. Kitchener thought this was too high, and said the cost should not exceed £5. Scott-Moncrieff was naturally puzzled, and it was some months later that he found out that Kitchener had based his estimate on the amount he had actually spent on hutting about 300 labourers employed on some work on his Kent estate. These, of course, had no officers' or sergeants' messes and no transport. When the first hutments were actually completed and the cost worked out, it was found that the average figure per head was about £15, which, allowing for the increased cost of materials, was very close to the original War Office figure. The cost of the sleeping huts for men only, with lavatory and ablution accommodation, was a little under £5, or very close to Lord Kitchener's figure.

GENERAL DETAILS OF HUTMENTS.

While the general question was being discussed, Col. Armstrong, in concert with the quartering and medical branches, had been preparing typical hutment plans for each class of unit. This involved in practice a complete revision of the barrack synopsis as

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regards not only the nature of buildings to be provided, but also the scales of accommodation, lighting, water supply and sanitary services. Some details may be usefully referred to here, as they explain some of our difficulties.

First as regards accommodation in sleeping rooms. This is calculated in terms of floor space and cubic space, the usual barrack allowance being 60 sq. feet and 600 cub. feet per head. It was early decided that the ordinary wooden hut without ceiling might be considered as having a cross section equivalent to an average height of 10 feet, so that in practice the cube might be neglected and we could make all our calculations in terms of floor space. It was also settled that with adequate ventilation the floor space might be reduced to 40 feet per man. A further figure has, however, to be kept in mind, and that is the minimum distance between beds, and this was fixed by the medical authorities at 5ft. from centre to centre.

The original huts designed by Col. Armstrong were 60 feet x 20 feet and designed to accommodate 30 men each. This size gives 40ft. floor space but only 4 feet of wall space per bed. The doors were placed at the ends, and there was room in the centre gangway for the two stoves supplied with each hut, and also for tables for meals. With the extended use of dining huts, such tables were not required, and later supplies of huts were designed 60 feet x 15 feet to accommodate 22 men each. These huts were usually sectional. With this width stoves must be placed against the side walls, taking the space of two beds.

The ventilation of huts is important and strict orders were issued that at least one window on each side must always be left open. Later arrangements were made to leave an opening along the whole length of each side just below the eaves. The walls were first unlined, but lining was allowed later and was added to the first built huts.

In the War Office type plans, these huts were arranged in rows with ablution rooms and latrines in blocks between every pair of rows. The number of basins and latrine seats provided was 4 per cent., which proved adequate. The ablution rooms were covered and had concrete floors, and were supplied with shelves on each side fitted with taps and loose basins. The latrines were also covered and with concrete floors.

Another important accessory was the bath-rooms, which usually consisted of 20 showers in one compartment, fitted in sets of five, each shower having hot and cold water supply. Opposite each shower a seat with pegs for clothes was provided for undressing and dressing. Two bath-rooms of this size were provided for each 1,000 men. This type is, however, capable of considerable improvement.

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The use of showers was adopted with the idea of providing a complete bath in the shortest possible time, but this advantage was entirely neutralized by placing the dressing accommodation so close to the showers. Assuming each man took 2½ minutes to bathe and 12½ minutes to dress and undress, the most economical arrangement would have been to provide five times as much dressing space as bathing space, and this proportion should always be maintained in designing bathing accommodation. Further, I am not satisfied that the shower system, though much used, is the best possible, especially when separate supplies of hot and cold water are provided. This gave rise to many accidents owing to the incautious use of hot water, and though we tried to render the apparatus fool-proof, none of the methods used proved quite satisfactory. The only safe way is to provide ample storage accommodation for the hot water, with arrangements to mix cold as required in the hot supply tank, so that the temperature at the taps never exceeds 100°F. In the original schemes for hutting, the water supply was based on an allowance of 5 gallons a head, but with the intensive use of baths this had to be increased to 10 gallons.

The arrangements for cooking and feeding for a battalion of infantry consisted of a central cook-house and two dining rooms capable of seating 500 in all at a time. The cooking was done on eight large 6-foot ranges of the ordinary commercial type, supplemented by eight Scotch boilers. The patterns were specially selected of commercial type to ensure ample supply, but the allowance proved unnecessarily liberal, and five ranges and four boilers were found sufficient for a battalion of 1,000 men. The cookhouse was arranged in one building with the ranges in the centre and the sinks and food tables round the walls. This is capable of improvement.

The dining rooms were at first constructed of a standard width of 30 feet, but later sectional huts were designed for a width of 28 feet. This width is convenient for recreation rooms, lecture halls and for similar large buildings.

It struck me as rather wasteful that these large dining rooms were used only for meals, and on my suggestion they were used at other times of the day for lectures, games, or at least for private reading and writing. They can also, in small units, be combined with the recreation establishment, and this was done in the later hutments.

The recreation establishment was, on the whole, a satisfactory design, and calls for no special comment.

The officers' and sergeants' messes were also satisfactory. No special sleeping accommodation was provided for sergeants, but in some cases a complete hut was allotted for this class, and in a few cases bunks were provided in certain huts. Officers' sleeping accommodation was divided into small compartments, each for two

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junior or one senior officer. These were satisfactory, except as regards heating. No bathrooms were provided for officers, but a boiler was provided in a separate compartment where water could be heated. The reason for this was a War Office ruling that the officers' quarters would not be furnished and officers were to use their camp kit, which includes a portable bath. When they did this they were allowed to draw camp allowance. If, however, fixed baths had been provided, this allowance could not be drawn. This ruling gave rise to some inconvenience, especially in hutments used by the Flying Corps, where a hot bath was considered a medical necessity after a flight of any duration.

The various barrack buildings were all heated by stoves.

The last buildings I propose to refer to were the drying rooms, where men were supposed to dry wet clothes. These were provided on a scale of one room for a company of 250 men, and were well designed, fitted with plenty of rails for hanging clothes and with a special ventilating stove to carry off the moistened air. The drying rooms were not popular, as men were very reluctant to leave their clothes unattended for fear of thefts. Some units started a system of cloak-room tickets, and this met the difficulty, but it involves the addition to the drying room of an ante-room for the use of the attendants in charge, with racks or compartments for dried clothes.

In addition to the preparation of these type plans, the War Office made special arrangements for the supply of huts, stoves and ranges. For these purposes standing contracts were made with all the principal makers of these articles, so that all the Commands had to do was to indent on the War Office, giving the number and destination of the huts, etc., and the War Office then distributed the order so as to equalize work between contractors. This arrangement worked admirably. At first huts were supplied of two widths, 20 feet and 30 feet, and of any length required, but later Armstrong designed sectional huts of 15 feet and 28 feet width, in sections of 10 feet. This width of section is rather large for transport and handling, but otherwise these huts answered well.

In 1916 the above were supplemented by a very light hut made of flat boards, which was very useful for small detachments.

Details of Work Done.

We may now consider some of the work done in connection with quarterings in the Eastern Command.

Barracks. The principal change made in barracks was the reduction of the scale of accommodation per head from 60 feet to 40 feet. This involved some increase in accessory buildings, which presented no difficulty.

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In addition, all married families were sent out of barracks and their quarters allotted to single men. For these, additional cooking accommodation was provided and also dining rooms. The difficulties which arose in these buildings are the same as in hired buildings, and are dealt with more fully later. The normal peace occupation of barracks in the Command was about 45,000 men. This was increased by the above methods to about 75,000.

New Hutments. I have already referred to how this group of services was started at the War Office, and the arrangements made to help commands. The hutting in the Eastern Command during 1914 and the early part of 1915 was mainly to provide for the increased garrisons of coast fortresses, and for the special centres for the divisions of the New Armies allotted to the Command. For the coast fortresses, the hutting required was in extension of existing barracks, and as there was plenty of land available and also connections to water and drainage systems, the difficulties met with were mainly matters for local settlement. For the New Armies the schemes were prepared at the War Office, sites selected and Command instructed to carry out the work. The Eastern Command had to provide accommodation for five divisions, and the centres selected were Colchester, Shorncliffe, Halton Park, Seaford and Shoreham. The first two included the barracks at these stations, which provided accommodation in each case for about a brigade of infantry and some details, leaving accommodation to be provided in huts for two brigades of infantry and for other arms. At Colchester the infantry, engineers and Army Service Corps were accommodated in huts on the military ground near the barracks, and the artillery in huts near Ipswich. The work was done by a special contractor on an agency contract, the only contract on this system in our Command. At Shorncliffe, the infantry were in a new hutment at Sandling, and the artillery, engineers and A.S.C. in scattered hutments near the barracks.

At Halton Park the whole of a division, except the artillery (about 15,000 in all,) was in new hutments in the Park on property belonging to the Rothschild family, who kindly gave the use of the house for the G.O.C. of the division. In this case a good water supply was available, but all drainage and most of the roads had to be constructed.

At Seaford the site was on golf links at the back of the town; some water and drainage was available but had to be supplemented. At Shoreham the site was also on golf links, with some water but no drainage. At both these centres the accommodation was for a whole division, less artillery, about 15,000 in all.

At all these centres many of the huts which were started in October, 1914, were occupied in November, 1914, but after about a month's occupation the troops were withdrawn into billets, and

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the hutments were not occupied again till about May, 1915. I will deal with the reasons for this a little later.

The total accommodation in hutments constructed by the Command up to March, 1915, was about 130,000 of all ranks.

The hutments built by the Central Force during the same period accommodated about 35,000 all ranks. They were built by the Chief Engineers of the three field Armies already referred to, and were based on the same War Office plans. The best known groups were those at Crowborough and Maresfield, which accommodated the greater part of a division.

In addition to these hutments, a system had been instituted under which various official and unofficial bodies who had undertaken to raise battalions, were allowed to provide hutments on a capitation basis, at first fixed at £7 a head and raised later to £12 10s. Soon after I joined, instructions were issued to the Commands to take over these units and their hutments and the Chief Engineers of each Command were required to certify that the money had been properly expended. This was rather difficult. Although the W.O. designs had been issued to these units they had not always been followed, but where the work had been entrusted to an experienced architect or builder, the final price came out about the same as the military rates, or £14 10s. to £15 a head. In other cases the rate varied considerably, one hutment costing £24 a head, and in one case I had to report an unsatisfactory system of lighting. The War Office, however, was not inclined to hold too tightly to the letter of its bond, and eventually all the hutments were taken over. They offered considerable variety of both planning and design. In one camp the sleeping accommodation was provided in large wood huts, each shaped like a church and holding 250 men. In another, where the construction of the huts and their arrangement was distinctly better than the W.O. design, all the cooking was done by steam and there was no arrangement for roasting meat! On the whole, the advantage of using local effort in this way far exceeded the disadvantages, and most of the latter would have been avoided if an engineer officer of the Command had been associated with the local Committee in the first place.

The number of hutments taken over was for 11 battalions in eight localities, or about 12,000 men in all.

In the summer of 1915 we received instructions to prepare hutments for use in the coming winter for various schools and instructional establishments, and for this purpose we used some of the places in the western half of the Command which had been abandoned by the Central Force. Of these I may mention an artillery school at Luton, and the group of signal schools at Haynes Park, Hitchen, Dunstable and Fenny Stratford. We had also a new programme of hutting for the Central Force at Thetford and other places in the

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Eastern Counties, and a large demand for extra accommodation for the Canadians at Shorncliffe. So that we had to prepare during the summer of 1915 schemes for the hutting of about 35,000 men. By the end of 1915 the hutting in the Command exceeded 200,000, distributed in 440 different groups. During 1916 the amount of new hutting was much less, but we were kept busy with alterations to suit the varying establishments of units, fitting up camps as convalescent depots with massage establishments, as well as work for the flying units, hospitals and miscellaneous establishments.

The erection of huts was only the beginning of our work. In March, 1915, the roads in the larger hutments were hardly marked out, lining had just been approved for the sleeping huts, while their outsides had to be coated with solignum, and when the troops went into occupation in May, 1915, we found that in most cases the water supply was insufficient, while the drainage arrangements were inadequate. The shortage of water was due to the demand for baths, and some of these had to be closed until we could double the size of the mains. As an instance, at Halton Park, though there was a large water system quite near, the main to the camp was too small to give sufficient head to distribute the water throughout the camp. We calculated we should require a branch 6" main for a length of 1,700 feet, and our contractors—Messrs. R. McAlpine and Sons—came to the rescue with a suggestion that they had on hand a suitable quantity of 7" piping, and offered to treat the matter as a rush job. Their estimate was £3,500, which was beyond the limit of our financial powers. With the approval of the M.G.A. I closed with the offer, obtaining W.O. approval in due course. The contractors finished the job in 14 days.

The drainage schemes for the larger hutments were prepared by a civilian engineer, selected by the War Office, and were designed for the bacteriological treatment of sewage with collecting or liquefying tanks, automatic dowsing tank and sprinkler beds. All these designs gave a good deal of trouble, partly because they were in all cases on too small a scale, owing to the under-estimate of the water consumption, and partly because sufficient allowance had not been made for the special conditions of military camps.

All our sewage systems had to stand a very severe test, as not only had they to pass the sanitary experts, but when the effluent ran into a watercourse we had to run the gauntlet of the various Fishery Boards.

In addition to these specially constructed systems of sewage disposal, almost every form of soak pit and irrigation system was tried. Soak pits are seldom satisfactory for a lengthy period, as when the soil is porous there is a risk of fouling the subsoil water,

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and when the soil is close the pits soon get choked and new ones have to be dug.

A very successful form of disposal for liquid sewage, ablution and cook-house water and urine, was suggested by Lt. Etherington, and first tried at the hutment at Denham, where a sprinkler system put in by a local architect failed to work, as the effluent produced was rejected by the Thames Conservancy authorities. Etherington suggested that the sewage should be well aerated by passing it slowly over the surface of a stretch of turf. He selected a piece of gently sloping ground about 100 feet square, and formed shallow furrows about half a spit deep along the contours. An attendant was detailed to keep the liquid from "ponding" and to shift the movement from one part of the area to another. The result was a satisfactory effluent.

Sites and Roads. I may conclude this section with some remarks on roads, with which I would embody some suggestions on the selection of sites for camps.

In all hutments or camps which are intended for extended occupation, there are three vital necessities which I will name in order of importance—Roads, Water and Drainage. Roads are required, not only for the use of the occupants, but for the use of the contractors forming the camp. Water is also needed for both purposes, while drainage for disposal of foul water is a matter of vital importance to the occupants. On the sites selected for the hutments there was generally some water supply available, but little or no drainage, while the question of roads was hardly considered.

Further, the hutments were designed in large blocks, necessitating the transfer of a large amount of material to the site, so that much of the grass surface round the huts was badly damaged in the process of erecting the huts. A grass surface is very good for a camp which is to be occupied for a short time in fine weather, but once it is cut up it rapidly deteriorates into a sea of mud. In 1914 the newly formed units were put into occupation of the partly finished hutments in November of a particularly wet winter, and having no experience of such conditions were ignorant of how to make the best of things. In most cases, also, the local transport added to the discomfort by driving on the grassy surface, cutting it to ribbons, and then, when one piece was spoilt, driving on to another patch. Had proper unloading points been marked off in the first place in the vicinity of the roads and paths constructed in the camps it should have been possible to use them through the winter.

When selecting a site for a hutment or camp for lengthy occupation, the best positions are likely to be found on the outskirts of towns. In a growing country like England there are always large areas laid out with roads, water, sewage and light, ready for the builder, which make admirable sites for hutments. Situated as

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they usually are between the town and the country, they get the benefits of both, as the country gives space for training grounds and rifle ranges, while the town gives accommodation for supplies, as well as water and light, and also some facilities for amusement and recreation, which, judiciously used, help the training. It is, of course, important not to crowd too many men on to one area, and in connection with this I evolved a theory that in any locality there is a limit to the number of men who can be "digested," that is, can be provided with water, sewerage and other necessities without overloading the local facilities. The large hutment at Seaford is a case in point. This is a small seaside town, but had sufficient accommodation for a brigade of about 5,000 men in addition to the population. To accommodate a whole division we had to enlarge both the water supply and also the drainage system.

In arranging the details of the hutment for any unit such as a battalion, it is necessary to carefully avoid following the usual barrack practice of arranging the buildings round the four sides of a parade or square. In barracks the parade being metalled forms a convenient means of intercommunication to the various buildings. In a temporary hutment the parades must be left in grass, and this forms an obstacle to communication. In such a case the best arrangement is to lay out the hutment on both sides of a good road, on to which all the buildings requiring special service should front. It is, of course, desirable to avoid main roads, but there are many places in England where existing second class roads could be used for this purpose, avoiding the necessity of entirely constructing new roads. A good layout would be to place the officers' mess, sergeants' mess and transport lines on one side, and the cook-house, recreation room and quartermaster's stores on the other. The officers' huts should be behind their mess, and the men's huts in company groups behind the recreation and dining rooms. Latrines must be placed near the road to facilitate water and drainage connections. The main guard room should be placed on the road at the end from which traffic will usually enter.

I have already stated that we obtained the assistance of the Road Board in making up our roads, and our first efforts were directed to making up one good road fit for motor traffic through each hutment. It was also necessary, to diminish the trouble from *mud*, to provide footpaths to each hut, and a certain amount of subsidiary roads for conservancy purposes and distribution of supplies. In most cases material for this was limited. It was suggested by one of my officers that old tins crushed flat would make very good bottoming for roads, and that the cinders from the cook-house and stoves would make a good surface. Both these articles were at the time accumulating in unsightly heaps, and in many camps special pits were dug to bury the tins out of sight.

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Instructions were therefore prepared in the C.E's. office for the preparation of the tins by burning to destroy scraps of food, and by crushing, and for the systematic laying out of roads and paths, and these instructions were embodied in a Command order which included some further points, such as the prohibition of short cuts across grass, the provision and use of scrapers to keep mud out of the huts, and similar details. These orders were called "Instructions for the prevention of mud in hutments," and whenever new units came into the command, copies were issued to all concerned.

The instruction to crush the tins brought at once a series of demands by telephone and letter for rollers to do the crushing. The answer was that if the local supply of rollers was inadequate a very good roller could be made out of a cylinder of concrete, while hand ramming would be effective. We heard no more of this, but the roads and paths in camps increased satisfactorily, and we heard little more of the trouble from mud. In a few camps, especially those on the Essex clay, the mud churned up by the passage of men and horses had become so bad that special measures had to be adopted, wooden walks provided between huts, and horse-watering points removed to the roads.

Hired Buildings. Of all the varied jobs which fell to my lot as Chief Engineer, Eastern Command, the action we took in organizing the accommodation in hired buildings always appears to me as being one of the most effective, not only on account of the large sums of money involved, but on account of the increased comfort and consequently increased efficiency which we were able to give to the troops.

On the outbreak of war it was necessary to make extensive use of hired buildings to accommodate the large number of men called to the colours. In some cases it was possible to adopt the system of billeting, under which the inhabitants are given the responsibility of feeding and housing a certain number of soldiers per household. But this did not meet the requirements, and it was necessary in addition to make use of every form of empty building, public halls, cinemas, schools and empty dwelling houses which could provide cover for troops.

In the peace organisation of our Army the responsibility of providing accommodation is divided between the R.E. and the R.A.S.C. The R.E. are responsible for the provision of all military buildings and for the taking over of any buildings hired on lease, that is for three years or upwards. The R.A.S.C., through the officer in charge of barracks, are responsible for the hiring of buildings for short terms under three years. In the large commands at home the barrack officers report to a District Barrack Officer who reports direct to the Q. branch of the staff, and not to the O.C. R.A.S.C. The object of this arrangement is that while the R.E.

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are responsible for the greater part of the accommodation, the barrack officer may supplement this accommodation to a minor extent and as a purely temporary measure.

But on the outbreak of war all hired accommodation is only required temporarily, and there could be no question of long leases. The responsibility of taking up all this new accommodation thus fell on the District Barrack Officer and his assistants. In the military centres the work was fairly well done, as assistance could be obtained from the R.E. in inspecting buildings and adapting them as required. In fact, when the building was a factory or store, considerable R.E. work was necessary, and provision of the accommodation was carried out as an engineer service.

But in the centres where there was no regular military staff, especially places occupied by the divisions of the Central Force, the work of taking over hired buildings was carried out by "Formation Committees" appointed by the troops under *Field Service Regulations*, and additions and alterations were made by the Formation Commander just as he would in a hostile area.

During the winter of 1914-15 all ranks were necessarily somewhat ignorant of the steps to take to maintain these buildings in a habitable condition, and the conditions were aggravated by a short supply of fuel, with the result that the troops supplemented the supply by taking any woodwork they could lay their hands on. The balustrades of staircases fell an early prey, and in some cases these were followed by the wooden porches of houses and other fittings, till in the spring of 1915 some of the places I visited looked as if they had suffered a bombardment. As long as the original units remained in occupation it was possible to bring home such damages to the offenders, but when early in 1915 whole divisions left for the Dardanelles and elsewhere, I began getting requests from my C.R.E.'s for assistance, and I found that in many cases in a single town a mass of over 1,000 claims for damages had been left in the R.E. office, and on enquiring for the Formation Committees I found that they had left with their units! Many of the buildings also were left in an almost uninhabitable condition. The whole question was reported formally and informally to the War Office, and our Major-General of Administration asked for my views on the question. I suggested that the first step seemed to be the appointment of permanent staff officers with the position of A.Q.M.G. covering the whole Command, who could act as permanent staff officers to the Commanding Officers of formations coming to the Command. At the time the Canadian troops were moving into Shorncliffe, and a permanent A.Q.M.G. was appointed to this centre, the right man for the job coming forward in the person of Col. F. H. S. Kincaid (late R.E.). But this suggestion only provided a framework, while we had to deal with a mass of details. The Quartering branch of

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the War Office worked out a scheme under which most of the well-known firms of House Agents and Surveyors were to be associated with local C.R.E's. for the purposes of investigating and assessing claims, *at a fee of three guineas a day*. This scheme was carried out, but proved quite useless, as our difficulty was not one of assessing claims, for which we had ample technical advice, but in settling whether a claim was reasonable or not, and also in *preventing claims arising in future*. The local firms of house agents were of no help on these points.

In the course of my visits I had been able to hear the views of my officers and to see many of the buildings which had been used by the troops. The points I noted were discussed very fully with Col. Hills and my staff. It was evident that if we were to do better in future we must be able to make a sufficient record of the condition of buildings at the beginning as well as at the end of our tenancy. It would be possible then to assess damages fairly accurately. It was also evident that this work must be done by a permanent organisation independent of the formations occupying the buildings, and in this connection it occurred to me that in the R.E. Lands branch we had an organisation doing almost exactly similar work in connection with damages to land. I therefore proposed to the Major General of Administration the provision of a body of House Valuers to look after accommodation in hired buildings. This was duly passed on to the War Office, and after some discussion was approved, except that the War Office decided that the new valuers should be obtained by an extension of our Lands branch, and we were asked to prepare a scheme accordingly and to say how many additional officers we wanted. While the combination of Lands and House work would have obvious advantages in sparsely occupied areas, there were many details to settle. With this in view the M.G.A. formed what afterwards became a "Command Quartering Committee," composed of the A.Q.M.G. of the Command, the A.Q.M.G. of the Central Force, the C.E. Eastern Command, the District Barrack Officer, with Colonel Hills as Secretary. As soon as we began to discuss the question it was evident that no one branch could undertake all the manifold duties involved, so that we were obliged to use the system of Committees, but formed of representatives of Administrative branches and not drawn from the troops. The whole area of the Command was considered and marked out into Quartering areas, about twenty-eight in number, and it was proposed that in each area there should be a standing Quartering Committee which would replace the Formation Committees and would consist of a representative of the Q. staff as President, the D.O. R.E. and O.i/c Barracks as members, with one of the newly-appointed House Agents as Secretary. These Committees overlapped as regards personnel in some cases, but this was

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unavoidable, as the areas controlled by individual barrack or engineer officers did not always coincide.

The scheme was duly approved and passed to the War Office with a request that suitable officers might be appointed as Presidents, but a reply was received that, while the scheme might be put into force, Presidents must be found from the senior officers in the Command. This was done and the scheme was worked under this arrangement for some months. It was a great improvement on what had gone before, but it was found that the Presidents having other duties were not in all cases able to give enough time to this special work. The value of the organisation having been proved, on a further application the War Office provided a number of senior officers, about fourteen in all, with the sole duty of looking after quartering. These were distributed to the more important areas, in some cases one officer becoming President of two or even three Committees.

Meanwhile, Col. Hills, as Secretary of the Command Committee, began drafting instructions to the local Committees as to the procedure to be followed in taking up houses. By this time I had seen a good deal of the working of the arrangements in the Command, and had come to a very definite conclusion that the methods adopted were capable of considerable improvement.

The procedure adopted by the old formation Committees up to that time based the taking up of buildings almost entirely on the accommodation required for sleeping; cooking was done in the building in which the men slept, and there was no provision for recreation establishments, lecture rooms or any central headquarters for each unit. When, as often happened, troops were distributed into detachments of 20 to 30 men each, discipline and training suffered, and the labour of distributing food and fuel was much increased. At the same time as each little detachment could not provide a cook, food was badly served. Our instructions to the new Committees thus took the following form:—

(1) To survey the accommodation in empty buildings in each locality and to then decide what class of units and how many could be accommodated in any town, and to divide the town into suitable unit areas.

(2) To set aside all the larger buildings in any unit area as dining and recreation rooms for a company, half battalion or battalion according to size.

(3) To group round these centres, sleeping accommodation in empty houses of any size, allotting certain houses for officers.

(4) To provide, near the central building, cook-houses, latrines and a central bathhouse, and also battalion headquarters, quartermaster's stores, etc., as required.

Under this arrangement, the men of each unit or sub-division of

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each unit were kept together all day in or near their centre, and only had to go to their sleeping places at night, and the detailed distribution of food and fuel was saved. Instructions were also issued as to the selection and allotment of training grounds and miniature ranges.

The Committees were further told that every important centre in their area should be gradually surveyed on the above lines, so that a scheme for accommodating new units might be got out at short notice, and this instruction proved very useful when the G.O.C. Home Forces changed the position of most of his troops early in 1916.

The number of Valuers appointed to the Command up to the end of 1916 reached a total of 20, making the total number of officers under the Chief Lands Officer up to 40. In many cases, these officers performed lands and house work, so that about 28 in all were more or less employed on work connected with houses. In busy centres each valuer dealt with about 500 houses, and as this was too much for one individual to handle, I authorized local C.R.E.'s to provide a staff for each valuer of one clerk and three or more foremen to prepare detailed schedules, note damages and supervise fittings. At the same time I instructed C.R.E.'s that these foremen might supervise any work on houses ordered by the D.O.R.E. at the request of the Quartering Committee. This resulted in the addition of abour 150 subordinates to our R.E. staff, which was none too many for the work to be handled.

As regards the actual work on individual buildings, Valuers were instructed to prepare a proper schedule of the conditions of the building when first occupied, and instructions were issued as to certain precautions which should be taken to prevent damage. Among these were the following: (1) The ordinary wooden staircases wore out very badly under the tread of heavy boots, so false treads of wood to take the wear were added in all cases. (2) Rifles, if leant against the wall, are liable to damage and themselves damage walls and plaster, so wooden arm racks were supplied. (3) Pegs and shelves must be provided, or men will use gas-fittings or knock nails into walls with damage to paper and plaster. (4) Valuable fittings such as fire-places, chandeliers, or wood carving must be protected.

For bath houses we abandoned the shower system and instructed the Committee to find a building or room with a concrete floor, to fit a water heating system with a few taps for hot and cold water round the sides of the building, and to provide receptacles for washing and pails to carry the water, also seats for dressing with pegs for clothes, in an area quite distinct from the bathing area. For baths it was suggested that the ordinary galvanised iron washing tub would

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make a good bath, and that one pail of hot water and one pail of cold would be sufficient allowance.

Of course, a new scheme of this sort could not be put into force without some difficulties arising. Many of these were due to the fact already referred to that the District Barrack Officer was responsible for taking over practically all the buildings occupied. Before he could do this he had to decide on a fair rent, and his technical adviser was necessarily the house valuer. The staff of the District Barrack officer had to be strengthened by the addition of assistants with legal training, to prepare and check the necessary agreements.

Although this complication of responsibilities did not result in any trouble at the Headquarters of the Command, it did result in some friction in the outlying stations, which was settled, generally, by the tact and good management of Col. Hills. But on the whole the scheme was an undoubted success, and not only added materially to the efficiency of the troops, but saved the British Taxpayer a very large sum of money.

(*To be continued.*)

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BATTLE HONOURS OF ROYAL ENGINEER UNITS.

N.B. "YPRES, 1917" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM PILCKEM TO CAMBRAI, 1917.

PILCKEM, 31ST JULY—2ND AUGUST, 1917.

BATTLE HONOURS OF ROYAL ENGINEER UNITS

ERRATA.

P. 253. Bapaume, 1917. Delete all units of II Corps as Irles is not a Battle Honour

P. 253. The note above Vimy, 1917, should read as follows:—
N.B.—"ARRAS, 1917," COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES OF ARRAS, VIZ., VIMY, FIRST SCARPE, SECOND SCARPE, ARLEUX, THIRD SCARPE.

P. 256. In last line, for *C* Corps read *G* Corps.

P. 257. For First Army XII Corps read First Army XIII Co. Corps.

P. 258. Scarpe, 1917 (Second Battle), 23rd-24th April.
Add to XVII Corps—

63rd Field Company.	9th Division	E.
64th ,, ,,	,,	E.
90th ,, ,,	,,	E.

233rd ,,	,,	,,
237th ,,	,,	,,
517th (London) Field Co.	47th Divn.	N.E.
518th ,,	,,	,,
520th ,,	,,	E.
II CORPS.		
1st Field Squadron.	1st Cav. Bde.	N.E.
2nd Field Co.	8th Divn.	E.
15th ,,	,,	,,
490th (Home Counties) Field Co.	,,	,,
79th Field Co.	18th Divn.	,,
80th ,,	,,	D.
92nd ,,	,,	N.E.
103rd Field Co.	24th Divn.	E.
104th ,,	,,	,,
129th ,,	,,	,,

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PILCKEM, 31ST JULY—2ND AUGUST, 1917.

Unit.	Formation.		Remarks.
II CORPS.			
105th Field Co.	25th Divn.	E.	
106th ,,	,,	,,	
130th ,,	,,	,,	
200th Field Co.	30th Divn.	,,	
201st ,,	,,	,,	
202nd ,,	,,	,,	
XIV CORPS.			
55th Field Co.	Guards Divn.	,,	
75th ,,	,,	,,	
76th ,,	,,	,,	
83rd Field Co.	20th Divn.	,,	
84th ,,	,,	N.E.	
96th ,,	,,	E.	
123rd Field Co.	38th Divn.	,,	
124th ,,	,,	,,	
151st ,,	,,	,,	
XVIII CORPS.			
225th Field Co.	39th Divn.	E.	
227th ,,	,,	,,	
234th ,,	,,	,,	
474th (S. Mid.) Field Co	48th Divn.	,,	
475th ,,	,,	,,	
477th ,,	,,	,,	
400th (Highland) Field Co.	51st Divn.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
XIX CORPS.			
73rd Field Co.	15th Divn.	,,	
74th ,,	,,	,,	
91st ,,	,,	,,	
155th Field Co.	16th Divn.	D.	Within area but not employed.
156th ,,	,,	N.E.	
157th ,,	,,	,,	
419th (West Lancs) Field Co.	55th Divn.	E.	
422nd ,,	,,	,,	
423rd ,,	,,	,,	

SIGNALS.

PILCKEM, 31ST JULY—2ND AUGUST, 1917.

Unit.	Formation		Remarks.
Second Army Signal Co.		N.E.	
X Corps. Signal Co.	X Corps	D.	
41st Divl. Signal Co.	41st Divn.	E.	
Fifth Army Signal Co.		N.E.	
B Corps Signal Co.	II Corps	D.	
8th Divl. Signal Co.	8th Divn.	E.	
18th ,,	18th ,,	,,	
24th ,,	24th ,,	,,	
25th ,,	25th ,,	,,	
30th ,,	30th ,,	,,	
J. Corps Signal Co.	XIV Corps	D.	
Guards Divl. Signal Co.	Guards Divn.	E.	
38th ,,	38th ,,	,,	
S. Corps Signal Co.	XVIII Corps	D.	
39th Divl Signal Co.	39th Divn.	E.	
51st ,,	51st ,,	,,	
T. Corps Signal Co.	XIX Corps	D.	
15th Divl. Signal Co.	15th Divn.	E.	
16th ,,	16th ,,	D.	
55th ,,	55th ,,	E.	

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LANGEMARCK, 1917. 16TH-18TH AUGUST, 1917.

Unit.	Formation.		Remarks.
SECOND AND FIFTH ARMIES.			
20th Army Troops Co.	XIV Corps	E.	
42nd ,,	II ,,	N.E.	
133rd ,,	II ,,	D.	
134th ,,	XIV ,,	E.	
135th ,,	XIV ,,	N.E.	
138th ,,	XIX ,,	E.	
141st ,,	XVIII ,,	N.E.	
145th ,,	II ,,	,,	
146th ,,	XIX ,,	E.	No diary.
235th ,,	II ,,	,,	
284th ,,	XVIII ,,	N.E.	
288th ,,	XIV ,,	,,	
568th ,,	XIX ,,	,,	
No. 4 Siege Co. R. Monmouth	X ,,	D.	
171st Tunnelling Co.	XIX ,,	E.	
173rd ,,	XIV ,,	,,	
177th ,,	II ,,	,,	
179th ,,	XVIII ,,	,,	
183rd ,,	XIV ,,	,,	
184th ,,	XVIII ,,	,,	
254th ,,	XIX ,,	,,	
255th ,,	XVIII ,,	,,	No diary.
No. 7 (Horsed) Pontoon Park	XIV ,,	N.E.	
No. 4 Army Tramway Co.	XVIII ,,	E.	
No. 5 ,,	XIX ,,	,,	
No. 6 ,,	XIV ,,	,,	
No. 9 ,,	II ,,	,,	
SECOND ARMY, X CORPS.			
225th Field Co.	39th Divn.	D.	
227th ,,	,,	N.E.	
234th ,,	,,	D.	
FIFTH ARMY, II CORPS.			
1st Field Squadron	1st Cav. Bde.	N.E.	
2nd Field Co.	8th Divn.	E.	
15th ,,	,,	,,	
490th (H.C.) Field Co.	,,	,,	
61st Field Co.	14th Divn.	N.E.	
62nd ,,	,,	,,	
89th ,,	,,	,,	
103rd ,,	24th Divn.	E.	
104th ,,	,,	,,	
129th ,,	,,	,,	
416th (Edinburgh) Fld. Co.	56th Divn.	,,	
512th (London) ,,	,,	,,	
513th ,, ,,	,,	,,	
XIV CORPS.			
55th Field Co.	Guards Divn.	N.E.	
75th ,,	,,	E.	
76th ,,	,,	,,	
83rd Field Co.	20th Divn.	,,	
84th ,,	,,	,,	
96th ,,	,,	,,	
455th (West Riding) Field Co.	29th Divn.	,,	
497th (Kent) Field Co.	,,	,,	
510th (London) ,,	,,	,,	
123rd Field Co.	38th Divn.	,,	
124th ,,	,,	,,	
151st ,,	,,	,,	

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LANGEMARCK, 1917, 16TH-18TH AUGUST, 1917.

Unit.	Formation		Remarks.
XVIII CORPS.			
67th Field Co.	11th Divn.	E.	
68th ,,	,,	,,	
86th ,,	,,	,,	
474th (S. Mid.) Field Co.	48th Divn.	,,	
475th ,,	,,	,,	
477th ,,	,,	,,	
XIX CORPS.			
73rd Field Co.	15th Divn.	N.E.	
74th ,,	,,	D.	
91st ,,	,,	N.E.	
155th ,,	16th Divn.	D.	Within area but not employed.
156th ,,	,,	N.E.	
157th ,,	,,	E.	
121st ,,	36th Divn.	,,	
122nd ,,	,,	,,	
150th ,,	,,	,,	
476th (S. Mid.) Field Co.	61st Divn.	D.	
478th ,,	,,	E.	
479th ,,	,,	D.	

SIGNALS.

LANGEMARCK, 1917. 16TH-18TH AUGUST, 1917.

Unit.	Formation.		Remarks.
2nd Army Signal Co.	2nd Army	N.E.	
X Corps Signal Co.	X Corps	D.	
39th Divl. Signal Co.	39th Divn.	,,	
5th Army Signal Co.	5th Army	N.E.	
B. Corps Signal Co.	II Corps	D.	
8th Divl. Signal Co.	8th Divn.	E.	
14th ,,	14th ,,	,,	
24th ,,	24th ,,	,,	
56th ,,	56th ,,	,,	
J. Corps Signal Co.	XIV Corps	D.	
20th Divl. Signal Co.	20th Divn.	E.	
29th ,,	29th ,,	,,	
38th ,,	38th ,,	D.	
S. Corps Signal Co.	XVIII Corps	,,	
11th Divl. Signal Co.	11th Divn.	E.	
48th ,,	48th ,,	,,	
T. Corps Signal Co.	XIX Corps	D.	
15th Divl. Signal Co.	15th Divn.	,,	
16th ,,	16th ,,	E.	
36th ,,	36th ,,	,,	
61st ,,	61st ,,	D.	

MENIN ROAD. 20TH-25TH SEPTEMBER, 1917.

Unit.	Formation		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
1st Field Squadron R.E.	X Corps	E.	
20th Army Troops Co.	XIV Corps	,,	
42nd ,,	I Anzac Corps	,,	
133rd ,,	,,	,,	
134th ,,	XIV Corps	,,	
135th ,,	,,	N.E.	
136th ,,		D.	No diary.
138th ,,	V Corps	E.	

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MENIN ROAD. 20TH-25TH SEPTEMBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
141st Army Troops Co.	XVIII Corps	N.E.	
145th ,,	I Anzac Corps	,,	
146th ,,		D.	No diary.
147th ,,		N.E.	
167th ,,	IX Corps	N.E.	
213th ,,		,,	
214th ,,		,,	
216th ,,	IX Corps	,,	
217th ,,	XVIII Corps	,,	
221st ,,	XIV Corps	,,	
235th ,,	I Anzac Corps	,,	
236th ,,	X Corps	D.	No. diary.
284th ,,	XVIII Corps	E.	
285th ,,		D.	No diary.
288th ,,	XIV Corps	N.E.	
290th ,,		,,	
554th ,,	VIII Corps	,,	
567th ,,	X Corps	,,	
568th ,,	V Corps	,,	
573rd ,,		,,	
6th Siege Co. R. Monmouth R.E.	X Corps	E.	
171st Tunnelling Co.	V Corps	,,	
173rd ,,	XIV Corps	,,	
175th ,,	X Corps	,,	No diary.
177th ,,	IX & VIII Corps	D.	
179th ,,	XVIII Corps	E.	
183rd ,,	XIV & XVIII Corps	,,	
250th ,,		D.	
253rd ,,	XVIII Corps	E.	
254th ,,	V Corps	,,	
255th ,,	XVIII Corps	D.	No diary.
1st Can. Tunnelling Co.	X Corps	E.	
2nd ,,	IX Corps	N.E.	
3rd ,,	X Corps	E.	
1st Aus. Tunnelling Co.	IX Corps	D.	No diary.
No. 351 E. & M. Co.		N.E.	
No. 354 ,,		,,	
No. 2 Field Survey Co.		D.	
No. 5 ,,		,,	
No. 2 Pontoon Park		,,	
No. 7 ,,	XIV & XVIII Corps	,,	
No. 4 Army Tramway Co.	XVIII Corps	E.	
No. 5 ,,	V & II Anzac Corps	,,	No diary.
No. 6 ,,	XIV Corps	,,	
No. 8 ,,	IX & VIII Corps	D.	No diary.
No. 9 ,,	X Corps	E.	No diary.
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
152nd ,,	37th Divn.	N.E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
X CORPS.			
97th Field Co.	21st Divn.	E.	
98th ,,	,,	N.E.	
126th ,,	,,	,,	

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MENIN ROAD. 20TH-25TH SEPTEMBER, 1917.

Unit.	Formation.	Remarks.
SECOND ARMY.		
X CORPS.		
101st Field Co.	23rd Divn.	E.
102nd ,,	,,	N.E.
128th ,,	,,	E.
11th ,,	33rd Divn.	,,
212th ,,	,,	,,
222nd ,,	,,	,,
225th ,,	39th Divn.	,,
227th ,,	,,	,,
234th ,,	,,	,,
228th ,,	41st Divn.	,,
233rd ,,	,,	,,
237th ,,	,,	,,
I ANZAC CORPS.		
1st Aust. Field Co.	1st Aust. Divn.	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
5th ,,	2nd Aust. Divn	,,
6th ,,	,,	,,
7th ,,	,,	,,
4th ,,	4th Aust. Divn.	,,
12th ,,	,,	,,
13th ,,	,,	,,
8th ,,	5th Aust. Divn.	,,
14th ,,	,,	,,
15th ,,	,,	,,
FIFTH ARMY.		
V CORPS.		
56th Field Co.	3rd Divn.	E.
438th ,,	,,	,,
529th ,,	,,	,,
63rd ,,	9th Divn.	,,
64th ,,	,,	,,
90th ,,	,,	,,
419th ,,	55th Divn.	,,
422nd ,,	,,	,,
423rd ,,	,,	,,
467th ,,	59th Divn.	,,
469th ,,	,,	,,
470th ,,	,,	,,
XIV CORPS.		
55th Field Co.	Guards Divn.	N.E.
75th ,,	,,	,,
76th ,,	,,	,,
83rd ,,	20th Divn.	E.
84th ,,	,,	,,
96th ,,	,,	,,
455th ,,	29th Divn.	,,
497th ,,	,,	,,
510th ,,	,,	,,
XVIII CORPS.		
400th Field Co.	51st Divn.	E.
401st ,,	,,	,,
404th ,,	,,	,,
503rd ,,	58th Divn.	,,
504th ,,	,,	,,
511th ,,	,,	,,
67th ,,	11th Divn.	,,
68th ,,	,,	,,
86th ,,	,,	,,

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SIGNALS.

MENIN ROAD. 20TH-25TH SEPTEMBER, 1917.

Unit.	Formation.		Remarks.
2nd Army Signal Co.		N.E.	
E Corps Signal Co.	IX Corps	D.	
19th Divl. Signal Co.	,,	E.	
37th ,,	,,	N.E.	
X Corps Signal Co.	X Corps	D.	
23rd Divl. Signal Co.	,,	E.	
33rd ,,	,,	,,	
39th ,,	,,	,,	
41st ,,	,,	,,	
K Corps Signal Co.	I Anzac Corps	D.	
1st Aust. Divl. Signal Co.	,,	E.	
2nd ,,	,,	,,	
4th ,,	,,	,,	
5th ,,	,,	,,	
5th Army Signal Co.		N.E.	
O Corps Signal Co.	V Corps	D.	
3rd Divl. Signal Co.	,,	E.	
9th ,,	,,	,,	
55th ,,	,,	,,	
59th ,,	,,	,,	
J Corps Signal Co.	XIV Corps	D.	
Guards Divl. Signal Co.	,,	E.	
20th ,,	,,	,,	
29th ,,	,,	,,	
S Corps Signal Co.	XVIII Corps	D.	
51st Divl Signal Co.	,,	E.	
58th ,,	,,	,,	
11th ,,	,,	,,	

POLYGON WOOD. 26TH SEPTEMBER—3RD OCTOBER, 1917.

Unit.	Formation		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
1st Field Squadron R.E.	X Corps	E.	
20th Army Troops Co.	XIV Corps	,,	
42nd ,,	I Anzac Corps	,,	
133rd ,,	,,	,,	
134th ,,	XIV Corps	,,	
135th	,,	N.E.	
138th ,,	II Anzac Corps	E.	
141st ,,	XVIII Corps	N.E.	
145th ,,	I Anzac Corps	E.	
146th ,,		D.	No diary.
147th ,,		N.E.	
167th ,,	VIII Corps	,,	
235th ,,	I Anzac Corps	D.	
284th ,,	XVIII Corps	E.	
6th Siege Co R. Monmouth	X Corps	,,	
171st Tunnelling Co	II Anzac Corps	D.	
173rd ,,	XIV Corps	E.	
175th ,,	X Corps	D.	No diary.
179th ,,	XVIII Corps	E.	
183rd ,,	XIV & XVIII Corps	,,	
250th ,,		D.	
253rd ,,	V Corps	E.	
254th ,,	V & II Anzac Corps	,,	
255th ,,	XVIII Corps	D.	No diary.
1st Can. Tunnelling Co.	X Corps	E.	
2nd ,,	IX Corps	,,	
3rd ,,	X Corps	,,	

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POLYGON WOOD. 26TH SEPTEMBER—3RD OCTOBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
No. 2 Pontoon Park	X & I Anzac Corps	,,	
No. 7 ,,	XIV & XVIII Corps	,,	
No. 4 Army Tramway Co	XVIII Corps	,,	
No. 5 ,,	V & II Anzac Corps	,,	No diary.
No. 6 ,,	XIV Corps	,,	
No. 8 ,,	IX Corps	,,	No diary.
No. 9 ,,	X Corps	,,	No diary.
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
152nd ,,	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
X CORPS.			
59th Field Co.	5th Divn.	E.	
491st ,,	,,	,,	
527th ,,	,,	D.	
54th ,,	7th Divn.	E.	
95th ,,	,,	,,	
528th ,,	,,	,,	
97th ,,	21st Divn.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	
101st ,,	23rd Divn.	N.E.	
102nd ,,	,,	,,	
128th ,,	,,	,,	
11th ,,	33rd Divn.	E.	
212th ,,	,,	,,	
222nd ,,	,,	,,	
225th ,,	39th Divn.	,,	
227th ,,	,,	,,	
234th ,,	,,	,,	
430th ,,	66th Divn.	,,	
431st ,,	,,	,,	
432nd ,,	,,	,,	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust Divn.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Divn.	,,	
6th ,,	,,	,,	
7th ,,	,,	,,	
4th ,,	4th Aust. Divn.	,,	
12th ,,	,,	,,	
13th ,,	,,	,,	
8th ,,	5th Aust. Divn.	,,	
14th ,,	,,	,,	
15th ,,	,,	,,	
II ANZAC CORPS.			
9th Aust. Field Co	3rd Aust. Divn.	E.	
10th ,,	,,	,,	
11th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	

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POLYGON WOOD. 26TH SEPTEMBER—3RD OCTOBER, 1917.

Unit.	Formation.	Remarks.
FIFTH ARMY. V CORPS.		
56th Field Co.	3rd Divn.	E.
438th ,,	,,	,,
529th ,,	,,	,,
467th ,,	59th Divn.	,,
469th ,,	,,	,,
470th ,,	,,	,,
XIV CORPS.		
9th Field Co.	4th Divn.	E.
406th ,,	,,	,,
526th ,,	,,	,,
83rd ,,	20th Divn.	,,
84th ,,	,,	,,
96th ,,	,,	,,
455th ,,	29th Divn.	,,
497th ,,	,,	,,
510th ,,	,,	,,
XVIII CORPS.		
67th Field Co.	11th Divn.	E.
68th ,,	,,	,,
86th ,,	,,	,,
474th ,,	48th Divn.	,,
475th ,,	,,	,,
477th ,,	,,	,,
503rd ,,	58th Divn.	,,
504th ,,	,,	,,
511th ,,	,,	N.E.
79th ,,	18th Divn.	E.
80th ,,	,,	D.
92nd ,,	,,	E.

SIGNALS.

POLYGON WOOD. 26TH SEPTEMBER to 3RD OCTOBER, 1917.

Unit.	Formation.	Remarks.
2nd Army Signal Co.		N.E.
E Corps Signal Co.	IX Corps	D.
19th Divl. Signal Co.	,,	E.
37th ,,	,,	,,
X Corps Signal Co.	X Corps	D.
5th Divl. Signal Co.	,,	E.
7th ,,	,,	,,
21st ,,	,,	,,
23rd ,,	,,	N.E.
33rd ,,	,,	E.
39th ,,	,,	,,
K Corps Signal Co.	I Anzac Corps	D.
1st Aust. Divl. Signal Co.	,,	E.
2nd ,,	,,	,,
4th ,,	,,	,,
5th ,,	,,	,,
Y Corps Signal Co.	II Anzac Corps	D.
3rd Aust. Divl Signal Co.	,,	E.
N.Z. ,,	,,	,,
5th Army Signal Co.		N.E.
O Corps Signal Co.	V Corps	D.
3rd Divl. Signal Co.	,,	E.
59th ,,	,,	,,
J Corps Signal Co.	XIV Corps	D.
4th Divl. Signal Co.	,,	E.
20th ,,	,,	,,
29th ,,	,,	,,
S Corps Signal Co.	XVIII Corps	D.
11th Divl. Signal Co.	,,	E.
48th ,,	,,	,,
58th ,,	,,	,,

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BROODSEINDE. 4TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
1st Field Squadron R.E.	X Corps	E.	
20th Army Troops Co.	XIV Corps	,,	
42nd ,,	I Anzac Corps	N.E.	
133rd ,,	,,	E.	
134th ,,	XIV Corps	,,	
138th ,,	II Anzac Corps	,,	
141st ,,	XVIII Corps	D.	
235th ,,	I Anzac Corps	N.E.	
283rd ,,	IX Corps	,,	
284th ,,	XVIII Corps	E.	
6th Siege Co. R. Monmouth	X Corps	,,	
171st Tunnelling Co.	II Anzac Corps	,,	
173rd ,,	XIV Corps	,,	
175th ,,	X Corps	D.	No diary.
179th ,,	XVIII Corps	E.	
183rd ,,	XIV & XVIII Corps	,,	
250th ,,		,,	
253rd ,,		,,	
254th ,,	II Anzac Corps	,,	
255th ,,	XVIII Corps	D.	No diary.
1st Can. Tunnelling Co.	X Corps	E.	
2nd ,,	IX Corps	,,	
3rd ,,	X Corps	,,	
No. 2 Pontoon Park		,,	
No. 7 ,,	XIV & XVIII Corps	,,	
No. 4 Army Tramway Co.	XVIII Corps	,,	
No. 5 ,,	II Anzac Corps	,,	No diary.
No. 6 ,,	XIV Corps	,,	
No. 8 ,,	IX Corps	,,	No diary.
No. 9 ,,	X Corps	,,	No diary.
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	D.	
94th ,,	,,	N.E.	
152nd ,,	37th Divn.	E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
X CORPS.			
59th Field Co.	5th Divn.	E.	
491st ,,	,,	,,	
527th ,,	,,	D.	
54th ,,	7th Divn.	E.	
95th ,,	,,	,,	
528th ,,	,,	,,	
97th ,,	21st Divn.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	
11th ,,	33rd Divn.	,,	
212th ,,	,,	,,	
222nd ,,	,,	,,	
430th ,,	66th Divn.	,,	
431st ,,	,,	,,	
432nd ,,	,,	,,	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust. Divn.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	

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BROODSEINDE, 4TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
I ANZAC CORPS.			
5th Aust. Field Co.	2nd Aust. Divn.	E.	
6th ,,	,,	,,	
7th ,,	,,	,,	
4th ,,	4th Aust. Divn.	N.E.	
12th ,,	,,	D.	Within area.
13th ,,	,,	E.	
II ANZAC CORPS.			
9th Aust. Field Co.	3rd Aust. Divn.	E.	
10th ,,	,,	,,	
11th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	
57th Field Co.	49th Divn.	,,	
456th ,,	,,	,,	
458th ,,	,,	N.E.	
FIFTH ARMY.			
XIV CORPS.			
9th Field Co.	4th Divn.	E.	
406th ,,	,,	,,	
526th ,,	,,	,,	
455th ,,	29th Divn.	,,	
497th ,,	,,	,,	
510th ,,	,,	,,	
XVIII CORPS.			
67th Field Co.	11th Divn.	E.	
68th ,,	,,	,,	
86th ,,	,,	,,	
79th ,,	18th Divn.	,,	
80th ,,	,,	D.	Within area.
92nd ,,	,,	E.	
474th ,,	48th Divn.	,,	
475th ,,	,,	,,	
477th ,,	,,	,,	

SIGNALS.

BROODSEINDE. 4TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
Second Army Signal Co.		N.E.	
E. Corps Signal Co.	IX Corps	D.	
19th Divl. Signal Co.	,,	,,	
37th ,,	,,	E.	
X Corps Signal Co.	X Corps	D.	
5th Divl. Signal Co.	,,	E.	
7th ,,	,,	,,	
21st ,,	,,	,,	
33rd ,,	,,	N.E.	
K. Corps Signal Co.	I Anzac Corps	D.	
1st Aust. Divl. Signal Co.	,,	E.	
2nd ,,	,,	,,	
4th ,,	,,	N.E.	
Y Corps Signal Co.	II Anzac Corps	D.	
3rd Aust. Divl. Signal Co.	,,	E.	
N.Z. Divl. Signal Co.	,,	,,	
Fifth Army Signal Co.		N.E.	
J. Corps Signal Co.	XIV Corps	D.	
4th Divl. Signal Co.	,,	E.	
29th ,,	,,	,,	
S. Corps Signal Co.	XVIII Corps	D.	
11th Divl. Signal Co.	,,	E.	
48th ,,	,,	,,	

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POELCAPPELLE. 9TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
1st Field Squadron	1st Cav. Divn.	D.	
20th Army Troops Co.	XIV Corps	E.	
42nd ,,	I Anzac Corps	N.E.	
133rd ,,	,,	E.	
134th ,,	XIV Corps	,,	
138th ,,	II Anzac Corps	,,	
145th ,,	I Anzac Corps	,,	
146th ,,	XVIII Corps	D.	
235th ,,	I Anzac Corps	N.E.	
283rd ,,	IX Corps	E.	
284th ,,	XVIII Corps	,,	
No. 6 Siege Co. R. Monmouth	X Corps	,,	
171st Tunnelling Co.	II Anzac Corps	,,	
173rd ,,	XIV Corps	,,	
175th ,,	X Corps	D.	No Diary
179th ,,	XVIII Corps	E.	
183rd ,,	XIV & XVIII Corps	,,	
250th ,,		,,	
253rd ,,		,,	
254th ,,	II Anzac Corps	,,	
255th ,,	XVIII Corps	D.	No diary.
1st Can. Tunnelling Co.	X Corps	E.	
2nd ,,	IX Corps	,,	
3rd ,,	X Corps	,,	
No. 2 Pontoon Park		,,	
No. 7 ,,	XIV & XVIII	,,	
No. 4 Army Tramway Co.	XVIII Corps	,,	
No. 5 ,,	II Anzac Corps	,,	
No. 6 ,,	XIV Corps	,,	
No. 8 ,,	IX Corps	,,	
No. 9 ,,	X Corps	,,	
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	,,	
94th ,,	,,	N.E.	
152nd ,,	37th Divn.	E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
X CORPS.			
59th Field Co.	5th Divn.	E.	
491st ,,	,,	N.E.	
527th ,,	,,	E.	
54th ,,	7th Divn.	D.	
95th ,,	,,	E.	
528th ,,	,,	,,	
61st ,,	14th Divn.	D.	
62nd ,,	,,	,,	
89th ,,	,,	E.	
97th ,,	21st Divn.	D.	
98th ,,	,,	E.	
126th ,,	,,	,,	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust. Divn.	D.	Within area.
2nd ,,	,,	E.	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Divn.	,,	
6th ,,	,,	,,	

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POELCAPPELLE. 9TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
I ANZAC CORPS.			
7th Aust. Field Co.	2nd Aust. Divn.	E.	
4th ,,	4th Aust. Divn.	N.E.	
12th ,,	,,	E.	
13th ,,	,,	,,	
8th ,,	5th Aust. Divn.	,,	
14th ,,	,,	,,	
15th ,,	,,	,,	
II ANZAC CORPS.			
57th Field Co.	49th Divn.	E.	
456th ,,	,,	,,	
458th ,,	,,	,,	
430th ,,	66th Divn.	,,	
431st ,,	,,	,,	
432nd ,,	,,	,,	
9th Aust. Field Co.	3rd Aust. Divn.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	
FIFTH ARMY.			
XIV CORPS.			
55th Field Co.	Guards Divn.	E.	
75th ,,	,,	,,	
76th ,,	,,	,,	
9th ,,	4th Divn.	,,	
406th ,,	,,	,,	
526th ,,	,,	,,	
455th ,,	29th Divn.	,,	
497th ,,	,,	,,	
510th ,,	,,	,,	
207th ,,	34th Divn.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
XVIII CORPS.			
63rd Field Co.	9th Divn.	E.	
64th ,,	,,	,,	
90th ,,	,,	D.	Within area.
67th ,,	11th Divn.	E.	
68th ,,	,,	,,	
86th ,,	,,	,,	
79th ,,	18th Divn.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
474th ,,	48th Divn.	,,	
475th ,,	,,	,,	
477th ,,	,,	,,	
247th ,,	63rd Divn.	,,	
248th ,,	,,	,,	
249th ,,	,,	,,	

SIGNALS.

POELCAPPELLE. 9TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
2nd Army Signal Co.		N.E.	
E. Corps Signal Co.	IX Corps	D.	
19th Divl. Signal Co.	,,	E.	
37th ,,	,,	,,	

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SIGNALS.

POELCAPPELLE. 9TH OCTOBER, 1917.

Unit.	Formation.	Remarks.
X Corps Signal Co.	X Corps	D.
5th Divl Signal Co	,,	E.
7th ,,	,,	,,
K. Corps Signal Co.	I Anzac Corps	D.
1st Aust. Divl. Signal Co.	,,	E.
2nd ,,	,,	,,
Y Corps Signal Co.	II Anzac Corps	D.
49th Divl. Signal Co.	,,	E.
66th ,,	,,	,,
5th Army Signal Co.		N.E.
J. Corps Signal Co.	XIV Corps	D.
Guards Divl. Signal Co.	,,	E.
4th ,,	,,	,,
29th ,,	,,	,,
S. Corps Signal Co.	XVIII Corps	D.
11th Divl. Signal Co.	,,	E.
48th ,,	,,	,,

PASSCHENDAELE (1ST BATTLE). 12TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
20th Army Troops Co.	XIV Corps	E.	
42nd ,,	I Anzac Corps	N.E.	
133rd ,,	,,	E.	
134th ,,	XIV Corps	,,	
138th ,,	II Anzac Corps	,,	
145th ,,	I Anzac Corps	,,	
146th ,,	XVIII Corps	D.	
235th ,,	I Anzac Corps	,,	
283rd ,,	IX Corps	E.	
284th ,,	XVIII Corps	,,	
No. 6 Siege Co. R. Monmouth	X Corps	,,	
171st Tunnelling Co.	II Anzac Corps	,,	
173rd ,,	XIV Corps	,,	
175th ,,	X Corps	D.	No diary.
179th ,,	XVIII Corps	E.	
183rd ,,	XIV & XVIII Corps	,,	
250th ,,		,,	
253rd ,,		,,	
254th ,,	II Anzac Corps	,,	
255th ,,	XVIII Corps	D.	No diary.
1st Can. Tunnelling Co.	X Corps	E.	
2nd ,,	IX Corps	,,	
3rd ,,	X Corps	,,	
2nd Pontoon Park		,,	
7th ,,	XIV & XVIII Corps	,,	
No. 4 Army Tramway Co.	XVIII Corps	,,	
No. 5 ,,	II Anzac Corps	,,	
No. 6 ,,	XIV Corps	,,	
No. 8 ,,	IX Corps	,,	
No. 9 ,,	X Corps	,,	

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PASSCHENDAELE (1ST BATTLE). 12TH OCTOBER, 1917.

Unit.	Formation.		Remarks.
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	,,	
94th ,,	,,	N.E.	
152nd ,,	37th Divn.	E.	
153rd ,,	,,	,,	
154th ,,	,,	,,	
X CORPS.			
59th Field Co.	5th Divn.	E	
491st ,,	,,	,,	
527th ,,	,,	,,	
54th ,,	7th Divn.	,,	
95th ,,	,,	,,	
526th ,,	,,	,,	
61st ,,	14th Divn.	,,	
62nd ,,	,,	D.	
89th ,,	,,	E.	
101st ,,	23rd Divn.	,,	
102nd ,,	,,	,,	
128th ,,	,,	,,	
I ANZAC CORPS.			
1st Aust. Field Co.	1st Aust. Divn.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Divn.	,,	
6th ,,	,,	,,	
7th ,,	,,	,,	
4th ,,	4th Aust. Divn.	,,	
12th ,,	,,	,,	
13th ,,	,,	,,	
8th ,,	5th Aust. Divn.	,,	
14th ,,	,,	,,	
15th ,,	,,	,,	
II ANZAC CORPS.			
57th Field Co.	49th Divn.	E.	
456th ,,	,,	,,	
458th ,,	,,	,,	
430th ,,	66th Divn.	,,	
431st ,,	,,	,,	
432nd ,,	,,	,,	
9th Aust. Field Co.	3rd Aust. Divn.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Divn.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	,,	,,	
FIFTH ARMY.			
XIV CORPS.			
55th Field Co.	Guards Divn.	D.	Within area but not employed.
75th ,,	,,	,,	Within area but not employed.
76th ,,	,,	,,	Within area but not employed.
9th ,,	4th Divn.	E.	
406th ,,	,,	,,	
526th ,,	,,	D.	

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PASSCHENDAELE (1ST BATTLE). 12TH OCTOBER, 1917.

Unit.	Formation.	Remarks.
XIV CGRPS.		
207th Field Co.	34th Divn.	D.
208th ,,	,,	E.
209th ,,	,,	D.
77th ,,	17th Divn.	E.
78th ,,	,,	,,
93rd ,,	,,	,,
XVIII CORPS.		
63rd Field Co.	9th Divn.	E.
64th ,,	,,	,,
90th ,,	,,	,,
67th ,,	11th Divn.	,,
68th ,,	,,	,,
86th ,,	,,	N.E.
79th ,,	18th Divn.	E.
80th ,,	,,	,,
92nd ,,	,,	,,
247th ,,	63rd Divn.	,,
248th ,,	,,	,,
249th ,,	,,	,,

SIGNALS.

PASSCHENDAELE (1ST BATTLE). 12TH OCTOBER, 1917.

Unit.	Formation.	Remarks.
2nd Army Signal Co.		N.E.
E Corps Signal Co.	IX Corps	D.
19th Divl. Signal Co.	,,	E.
37th ,,	,,	,,
X Corps Signal Co.	X Corps.	D.
14th Divl. Signal Co.	,,	E.
23rd ,,	,,	,,
K Corps Signal Co.	I Anzac Corps	D.
4th Aust. Divl. Signal Co.	,,	E.
5th ,,	,,	,,
Y Corps Signal Co.	II Anzac Corps	D.
3rd Aust. Divl. Signal Co.	,,	E.
N.Z. Divl. Signal Co.	,,	,,
5th Army Signal Co.		N.E.
J Corps Signal Co.	XIV Corps	D.
Guards Divl. Signal Co.	,,	E.
4th ,,	,,	,,
17th ,,	,,	,,
S Corps Signal Co.	XVIII Corps	D.
9th Divl. Signal Co.	,,	E.
18th ,,	,,	,,

PASSCHENDAELE (SECOND BATTLE). 26TH OCTOBER-10TH NOVEMBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
20th Army Troops Co.	XIV & XIX Corps	E.	
42nd ,,	I Anzac Corps	,,	
133rd ,,	,,	,,	
134th ,,	XIV Corps	,,	
135th ,,	XIX Corps	,,	
136th ,,		D.	No diary.
138th ,,	Canadian Corps	E.	
141st ,,	XVIII & II Corps	N.E.	
145th ,,	I Anzac Corps	E.	
146th ,,	XVIII Corps	,,	

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PASSCHENDAELE (2ND BATTLE). 26TH OCTOBER-10TH NOVEMBER, 1917.

Unit.	Formation.		Remarks.
2ND AND 5TH ARMIES.			
ARMY TROOPS.			
147th Army Troops Co.		N.E.	
213th ,,		,,	
214th ,,		,,	
216th ,,		,,	
217th ,,	XVIII Corps	,,	
221st ,,	II Corps	,,	
235th ,,	I Anzac Corps	E.	
236th ,,		D.	No diary.
283rd ,,	IX Corps	E.	
284th ,,	XVIII & II Corps	,,	
285th ,,		D.	No diary.
288th ,,	XIV & XIX Corps	N.E.	
567th ,,	X Corps	,,	
568th ,,		,,	
573rd ,,		,,	
2nd Can. Army Troops Co.	Canadian Corps	D.	
4th ,,	,,	E.	
5th ,,	,,	,,	
No. 6. Siege Co. R. Monmouth	X Corps	,,	
171st Tunnelling Co.	Canadian Corps	,,	
173rd ,,	XIV & XIX Corps	,,	
175th ,,	X Corps	D.	No diary.
179th ,,	XVIII & II Corps	E.	
183rd ,,	XIV & XIX Corps	,,	
250th ,,		D.	
253rd ,,	XIV & XIX Corps	E.	
254th ,,	Canadian Corps	,,	
255th ,,	XVIII & II Corps	,,	No diary.
1st Can. Tunnelling Co.	X Corps	,,	
2nd ,,	IX Corps	D.	
3rd ,,	X Corps	E.	
1st Aust. Tunnelling Co.		D.	No diary.
351st E. & M. Co.		N.E.	
354th ,,		D.	
2nd Field Survey Co.		,,	No diary.
5th ,,		,,	
No. 2 Pontoon Park	Can. & I Anzac Corps	E.	
No. 6 ,,	II Corps	D.	
No. 7 ,,	II & XIX Corps	E.	
No. 4 Army Tramway Co	XVIII & II Corps	,,	
No. 5 ,,		D.	No diary.
No. 6 ,,	XIV & XIX Corps	E.	
No. 8 ,,	IX Corps	,,	No diary.
No. 9 ,,	X Corps	,,	No diary.
SECOND ARMY.			
IX CORPS.			
81st Field Co.	19th Divn.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
152nd ,,	37th Divn.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	

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PASSCHENDAELE (2ND BATTLE). 26TH OCTOBER-10TH NOVEMBER, 1917.

Unit.	Formation	Remarks.
X CORPS.		
59th Field Co.	5th Divn.	E.
491st ,,	,,	,,
527th ,,	,,	,,
54th ,,	7th Divn.	,,
95th ,,	,,	,,
528th ,,	,,	,,
61st ,,	14th Divn.	,,
62nd ,,	,,	,,
89th ,,	,,	,,
97th ,,	21st Divn.	,,
98th ,,	,,	,,
126th ,,	,,	,,
101st ,,	23rd Divn.	N.E.
102nd ,,	,,	,,
128th ,,	,,	,,
225th ,,	39th Divn.	E.
227th ,,	,,	,,
234th ,,	,,	,,
I ANZAC CORPS.		
1st Aust. Field Co.	1st Aust. Divn.	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
5th ,,	2nd Aust. Divn.	,,
6th ,,	,,	,,
7th ,,	,,	,,
8th ,,	5th Aust. Divn.	,,
14th ,,	,,	,,
15th ,,	,,	,,
CANADIAN CORPS.		
1st Can. Field Co.	1st Can. Divn.	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
4th ,,	2nd Can. Divn.	,,
5th ,,	,,	,,
6th ,,	,,	,,
7th ,,	3rd Can. Divn.	,,
8th ,,	,,	,,
9th ,,	,,	,,
10th ,,	4th Can. Divn.	,,
11th ,,	,,	,,
12th ,,	,,	,,
FIFTH ARMY. (Passed to 2ND ARMY, 1st November, 1917).		
XVIII CORPS (relieved by II CORPS, 2nd November, 1917).		
79th Field Co.	18th Divn.	E.
80th ,,	,,	,,
92nd ,,	,,	,,
206th ,,	32nd Divn.	D.
218th ,,	,,	E.
219th ,,	,,	,,
503rd ,,	58th Divn.	,,
504th ,,	,,	,,
511th ,,	,,	,,
247th ,,	63rd Divn.	,,
248th ,,	,,	,,
249th ,,	,,	,,
II CORPS.		
23rd Field Co.	1st Divn.	E.
26th ,,	,,	,,
409th ,,	,,	,,
5th ,,	2nd Divn.	,,
226th ,,	,,	,,
483rd ,,	,,	,,

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PASSCHENDAELE (2ND BATTLE). 26TH OCTOBER-10TH NOVEMBER, 1917.

Unit.	Formation.	Remarks.
XIV CORPS (relieved by XIX CORPS, 29th October, 1917).		
203rd Field Co.	35th Divn.	E.
204th ,,	,,	,,
205th ,,	,,	,,
7th ,,	50th Divn.	,,
446th ,,	,,	,,
447th ,,	,,	,,
421st ,,	57th Divn.	,,
502nd ,,	,,	,,
505th ,,	,,	,,
XIX CORPS.		
77th Field Co.	17th Divn.	E.
80th ,,	,,	,,
92nd ,,	,,	,,

SIGNALS.

PASSCHENDAELE (2ND BATTLE) 26TH OCTOBER-10TH NOVEMBER, 1917.

Unit.	Formation.	Remarks.
Second Army Signal Co.		N.E.
B. Corps Signal Co.	II Corps.	D.
1st Divl. Signal Co.	,,	E.
58th ,,	,,	,,
63rd ,,	,,	,,
E. Corps Signal Co.	IX Corps	D.
19th Divl. Signal Co.	,,	E.
37th ,,	,,	,,
X Corps Signal Co.	X Corps	D.
5th Divl. Signal Co.	,,	E.
7th ,,	,,	,,
14th ,,	,,	N.E.
21st ,,	,,	E.
23rd ,,	,,	N.E.
39th ,,	,,	E.
Can. Corps Signal Co.	Canadian Corps	D.
1st Can. Divl. Signal Co.	,,	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
4th ,,	,,	,,
K. Corps Signal Co.	I Anzac Corps	D.
1st Aust. Divl. Signal Co.	,,	E.
2nd ,,	,,	,,
5th ,,	,,	,,
Fifth Army Signal Co.		N.E.
J. Corps Signal Co.	XIV Corps	D.
35th Divl. Signal Co.	,,	E.
50th ,,	,,	,,
57th ,,	,,	,,
S. Corps Signal Co.	XVIII Corps	D.
T. Corps Signal Co.	XIX Corps	,,
17th Divl. Signal Co.	,,	E.
18th ,, ,,	,,	,,

CAMBRAI 1917. 20TH NOVEMBER—3RD DECEMBER, 1917.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
A. Special (Cyl.) Co.	Special Brigade	N.E.
G. ,,	,,	E.
P. ,,	,,	,,
Q. ,,	,,	D.

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CAMBRAI, 1917. 20TH NOVEMBER—3RD DECEMBER, 1917.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
No. 1 Special (Mortar) Co.	Special Brigade	E.	
No. 3 ,,	,,	N.E.	
142nd Army Troops Co.	IV Corps	E.	
147th ,,	V Corps	,,	
149th ,,	IV Corps	D.	
232nd ,,	III Corps	E.	
238th ,,	VII Corps	N.E.	
239th ,,	III Corps	E.	
280th ,,		N.E.	
281st ,,	VII Corps	,,	
559th ,,	V Corps	E.	
565th ,,	IV Corps	,,	
574th ,,	III & VII Corps	,,	No diary.
577th ,,	IV Corps	,,	No diary.
No. 2 Siege Co. R. Anglesey	IV Corps	,,	
178th Tunnelling Co.	III & VII Corps	,,	
180th ,,	VII Corps	D.	
181st ,,	III Corps	E.	
252nd ,,	V Corps	,,	
1st Aust. ,,	IV Corps	D.	
N.Z. ,,	IV Corps	,,	
No. 352 E. & M. Co.		,,	No diary.
No. 353 ,,		,,	No diary.
No. 3 R.E. Workshop		,,	No diary.
No. 3. Field survey Co.		,,	No diary.
No. 3 Pontoon Park (Horsed)	III & IV Corps	E.	
No. 8 Pontoon Park (M.T.)	,,	,,	
No. 1 Army Tramway Co.		D.	
No. 3 ,,	III Corps	E.	
CAVALRY CORPS.			
1st Field Squadron	1st Cav. Divn.	E.	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	N.E.	
4th ,,	4th ,,	E.	
5th ,,	5th ,,	,,	
II, IV, V AND VII CORPS.			
55th Field Co.	Guards Divn.	E.	
75th ,,	,,	,,	
76th ,,	,,	,,	
5th ,,	2nd Divn.	,,	
226th ,,	,,	,,	
483rd ,,	,,	,,	
56th ,,	3rd Divn.	N.E.	
438th ,,	,,	,,	
529th ,,	,,	,,	
12th ,,	6th Divn.	E.	
459th ,,	,,	,,	
509th ,,	,,	,,	
69th ,,	12th Divn.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
83rd ,,	20th Divn.	,,	
84th ,,	,,	,,	
96th ,,	,,	,,	
97th ,,	21st Divn.	N.E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
455th ,,	29th Divn.	,,	
497th ,,	,,	,,	
510th ,,	,,	,,	

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CAMBRAI, 1917. 20TH NOVEMBER—3RD DECEMBER, 1917.

Unit.	Formation.	Remarks.
II, IV, V AND VII CORPS.		
121st Field Co.	36th Divn.	E.
122nd ,,	,,	,,
150th ,,	,,	,,
224th ,,	40th Divn.	,,
229th ,,	,,	,,
231st ,,	,,	,,
517th ,,	47th Divn.	,,
518th ,,	,,	,,
520th ,,	,,	,,
400th ,,	51st Divn.	,,
401st ,,	,,	,,
404th ,,	,,	,,
419th ,,	55th Divn.	,,
422nd ,,	,,	,,
423rd ,,	,,	,,
416th ,,	56th Divn.	,,
512th ,,	,,	,,
513th ,,	,,	,,
467th ,,	59th Divn.	,,
469th ,,	,,	,,
470th ,,	,,	,,
476th ,,	61st Divn.	,,
478th ,,	,,	,,
479th ,,	,,	,,
457th ,,	62nd Divn.	,,
460th ,,	,,	,,
461st ,,	,,	,,

SIGNALS.

CAMBRAI 1917. 20TH NOVEMBER—3RD DECEMBER, 1917.

Unit.	Formation.	Remarks.
Third Army Signal Co.		D.
Cavalry Corps. Signal Sqn.	Cav. Corps	E.
1st Signal Sqn.	1st Cav. Divn.	,,
2nd ,,	2nd ,,	,,
4th ,,	4th ,,	,,
5th ,,	5th ,,	,,
C. Corps Signal Co	III Corps	D.
D. ,,	IV Corps	,,
O. ,,	V Corps	,,
G. ,,	VII Corps	,,
Guards Divl Signal Co.		E.
2nd ,,		,,
3rd ,,		D.
6th ,,		E.
12th ,,		,,
20th ,,		,,
21st ,,		,,
29th ,,		,,
36th ,,		,,
40th ,,		,,
47th ,,		,,
51st ,,		,,
55th ,,		,,
56th ,,		,,
59th ,,		,,
61st ,,		,,
62nd ,,		,,

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HYDRO-ELECTRIC DEVELOPMENT IN FRANCE.

By CAPTAIN D. FITZJ. FITZMAURICE. R.E.

The utilisation of water-power, "Houille Blanche," or "white coal," was more or less forced on France by the shortage of black coal during the Great War. This is not to say that no considerable exploitation of her water-power resources had been undertaken previous to 1914; on the contrary, France claims the credit for some of the earliest experimental and practical work in this direction.

In 1827, Fourneyron invented his Pressure Turbine which was to oust the old waterwheel, and to be the forerunner of the Francis Turbine of the present day. In the sixties, Aristide Bergés to whom the name of "Houille Blanche" is due, was installing water-power stations for the paper industry in the Dauphiné Alps, and many other pioneers soon followed in his footsteps. In 1870 the curved buckets of the Cascade wheel, the prototype of the present day Pelton, were first employed. It was not, however, till the eighties that, as a result of electrical developments, it became possible to transmit power to a distance, with the natural corollary that the utilization of water-power situate at a considerable distance from centres of Industry became an economic commercial possibility. The earlier turbines had been more or less direct-coupled to the machines they served, gearing, belts and shafting, and even the endless cable soon reaching their economic limit. In the nineties, however, 3-phase high-tension current was being transmitted over distances up to 100 miles.

In 1899, the first really important Hydro-electric power station in France was completed at Champ-sur-le-Drac (Isére), with an installed capacity of 10,000 h.p. under a head of 118 ft. As might be expected, the Alpine Region, the Dauphiné and Savoie, was the cradle of the hydro-electric movement in France. 1900 saw the foundation of the *Institut Electro-Technique* in the University town of Grenoble, where in 1901 the *Syndicat des Forces Hydrauliques* was formed, while in 1902, this town held the first *Congrés de la Houille Blanche.*

In 1903, the *Ministère de l'Agriculture*, in conjunction with the *Ministère des Travaux Publics*, inaugurated the *Service d'Etudes des Grandes Forces Hydrauliques*, whose researches into the availability of power in the various river basins are published periodically by the *Imprimerie Nationale.* It is the function of this Service to

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obtain and collate full information as to the characteristics of river basins, with a view to their ultimate development for power purposes. This includes the making of accurate surveys of the valleys and the plotting of periodical profiles of the watercourses; geological investigations; the compilation of rainfall and discharge statistics; the time of floods and their duration and the observation of the nature and quantity of matters carried by the streams in suspension.

By 1914, about 1½ millions of h.p. had been harnessed in the whole of France. The Great War, with its abnormal demands on the factories, and the coal famine existing on the continent from 1916 onwards, gave a great impulse to the development of water-power, with the result that the amount of installed h.p. now reaches 2½ millions, of which some 1¾ millions are in the Alpine region. (*)

In 1925 the third *Congrès de la Houille Blanche* was held in Grenoble, the town that has fostered water-power in France since its earliest infancy, and where the mountains and rivers that gave it its early importance as a military stronghold now provide it with the power for its industries.

Geographical Distribution of Water-Power in France.

The most important, and by far the most numerous works are to be found in the Alpine region, where some 70% of the total of installed h.p. in the whole country is located.

The region of the Pyrenees is the next in order of importance, with about 20% of the total; the largest individual station being that of Eget (35,000 h.p.), on the river Neste, a tributary of the Garonne.

The *Massif Central* supplies the majority of the remainder. The natural heads available here are small, and have almost invariably to be increased by the construction of dams, artificial lakes being thus formed to increase the storage. The most recently opened station in this region is at Eguzon on the river Creuze (75,000 h.p.), where a barrage 200 ft. high and 840 ft. long has been built: the power is to be utilised for the electrification of the Paris-Orleans railway system, and to supply light and power to Paris.

General Considerations.

While the undertakings for these installations can be grouped broadly as "high head" and "low head" works, using respectively the Pelton wheel and the Francis turbine as prime movers, no two schemes are quite alike, the variations being due *inter alia* to the discharge characteristics of the streams to be harnessed, the general configuration of the ground, and the choice of the most suitable site for the power station itself.

The determination of the discharge characteristic of the stream is the all-important factor on which the project for the utilisation

* "La Houille Blanche" V. Sylvestre, 1925.

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of the water must be based; and the variability of the discharge is one of the inherent difficulties in the economic utilisation of water-power. While the mountain torrent fed by glaciers will give its maximum discharge in the summer months due to the melting of ice and snows, and its minimum discharge in winter when its sources are more or less ice-bound; with streams in the plains, fed only by rains and occasional snow, the reverse will be the case. The variation in discharge will also be largely affected by the slope and permeability of the surface strata of the basin, the rise of floods being much more rapid where the majority of the rainfall runs off direct down steep slopes to the watercourses, than where the latter are fed largely by percolation.

The discharge regulation can be improved by the construction of dams and storage reservoirs, but such works are very costly, and other means of regulation are sought where possible. Manifestly in the case of a river of the plains fed by both winter rains and the summer discharge of a glacial tributary, a considerable natural improvement is effected in the discharge regulation. Such a situation occurs, for example, at the confluence of the Drac and the Romanche, close to Grenoble, where a low-head power station was completed in 1921. Further, it is sometimes possible to connect electrically two or more stations working under different seasonal discharge conditions, in order to be in a position to deliver a more or less constant output to the network; while in some cases a natural lake has been tapped as a reservoir to supplement the low water discharge of a river. A case in point is the power station of Le Baton (Isére), where the surplus river water at maximum discharge is pumped back to refill the lake.

As in most river works, the quantity of sand or silt brought down in suspension is of the utmost importance. Not only must arrangements be made for excluding it as far as possible from the turbines, where it is likely to cause erosion of the runners and guide-passages, but the danger of silting-up of reservoirs has also to be considered.

The quantity of granitic sand brought down by the Alpine torrents is large, and the full head behind a dam cannot always be relied on for this reason; the bottom of the reservoir being considered as a depository for sand accumulations. Special residuum lodges can also be provided at the upstream end of the reservoir, where the velocity of the incoming water must be sufficiently checked to make further transport of the sand or silt impossible.

The tendency of a reservoir to silt up and its effect in clarifying the waters feeding it, are well illustrated by the Lake of Geneva. The Rhone, at its entrance to the lake, is very turbid indeed, but the turbidity ceases a very short way from the upstream end of the lake, and at Geneva a clear Rhone flows out, only however, to be fouled a little further on by the blue grey waters of the Arve

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flowing in from the direction of Chamonix and the great glaciers of the Mont Blanc range. The foreshore at the upstream end of the lake is steadily advancing under the continuous action of the silt-deposit.

Nature of the Works.

The works required on the Civil Engineering side of a project for the utilisation of water-power may be roughly grouped as:

(1) The Intake works, and Head-race or Approach channel;
(2) The Power House;
(3) The Tail-race Works;

and in addition, any temporary works which may be necessary to facilitate access to, and transport of men and material to, the works.

Where large storage works are necessary these will often form one of the most important and costly items in the project. For this reason they are avoided wherever possible, and sites chosen for development where a sufficiently continuous flow or natural storage facilities are available.

Typical Developments are:

(*a*). A natural cascade diverted into a water chamber hollowed in the rock, and thence piped down either above or below ground to the turbines or Pelton wheels. (Fig. 1).

(*b*). A high level lake, natural or artificial, tapped by tunnel or canal, and the water then led some distance, maybe, to a neighbouring gorge where a good fall is obtainable by pipe line to a low-level power station. (Fig. 2).

(*c*). A deep and narrow river gorge closed by a masonry or concrete dam, usually built arch-shaped in plan; the water being piped to the power-station situated near the foot of the dam. (Fig. 3).

(*d*). A steady-flowing river of the plains, harnessed by a low barrage, carrying movable weirs above the fixed crest for passing the flood waters; the power station being sited either in the river bed itself at the barrage, or being reached by an approach canal, advantage being taken of a further fall in the river bed to get a low level for the tail-race discharge. (Figs. 4 and 5).

High-Head Works.

Type (*a*). This type of development lends itself particularly to the case where a high head is available and only a small quantity of water. This development is, therefore, commonest in the Alpine Region proper. By a high head is meant 500 ft. or over, and for such heads the Pelton wheel is generally preferred as prime-mover, on account of its high economical speed as compared with the Francis turbine.

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The Pelton wheel, as is well known, consists essentially of a disc mounted on a horizontal spindle and carrying a number of buckets (about 20) bolted to its periphery, the wheel being rotated by the impulse of a high velocity jet playing on the buckets, tangentially to the wheel.

The buckets are designed:

(i) To receive the jet with the minimum of shock, or loss of energy.

(ii) To change the direction of the jet through nearly 180 degrees (with the stipulation that the oncoming bucket shall be cleared by the water thrown off), and to throw the water off "dead," *i.e.*, to convert its available momentum into an impulsive force tangential to the wheel.

To achieve the above, the buckets normally take the form of the open bivalve (Fig. 6), with a sharp central ridge to divide the jet, and external edges splayed slightly outwards from the plane of the disc. A lip is usually removed, as shewn, to avoid the splashing (and consequent loss of energy) that would be caused by the deflection of some of the water radially inwards towards the centre of the wheel, by the lip, if allowed to remain. The central ridge is curved back in the plane of the wheel so as to meet the incoming jet at right angles. The convex back of the bucket is strengthened by ribs as necessary.

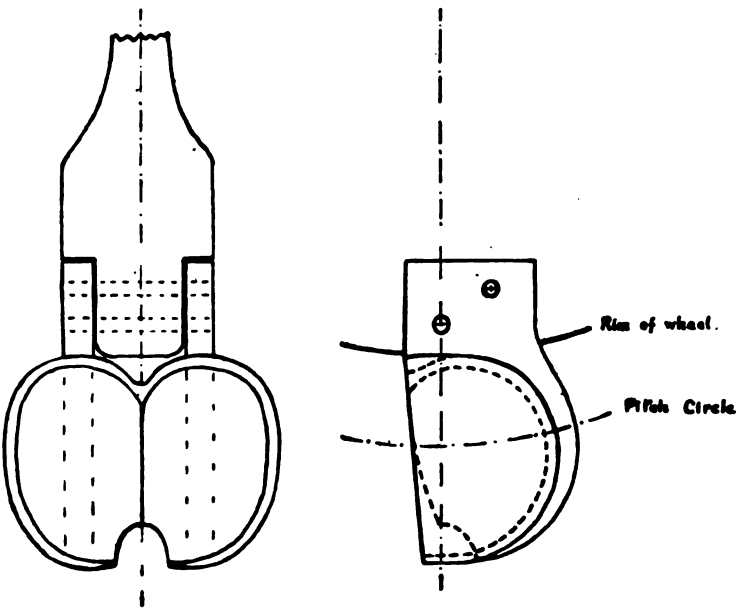

FIG. 6.

Bucket of Pelton Wheel.

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As a rough rule, 1 inch of jet diameter is given to every foot of wheel diameter; and the bucket width is made about four times the jet diameter; while the length of the bucket measured along a radius of the wheel should be sufficient to ensure that no part of the jet escapes unused. The most efficient bucket speed is about ·46 times the jet velocity.

The jet is usually of the needle valve type, controlled by a hydraulic relay regulator operated by a centrifugal governor. To obviate the disastrous effect of water hammer under the great pressures employed, either a relief valve is fitted at the lower end of the pipe line, or a deflecting nozzle is employed cutting off the supply to the buckets without altering the flow in the pipe line. The pipe line velocity must be kept down to avoid heavy friction losses, and in practice seldom exceeds 15 to 20 ft.-sec. The water thus arrives under great pressure at the nozzle, where its pressure energy is converted into kinetic.

If D and V are the diameter and the velocity in the pipe line, and d and v are the diameter and velocity at the nozzle, then for continuity of flow,

$$\frac{\pi.D^2.V}{4} = \frac{\pi.d^2.v}{4}$$

or

$$\frac{D^2}{d^2} = \frac{v}{V}$$

Also, $v = \cdot 985\ \sqrt{2gh}$, where h is the effective head at nozzle.

h = H (total head) — H′ (pipe line losses).

The pipe line must be designed to keep H′ down within economical limits.

If Q be the quantity of water available in cusecs, the theoretical power obtainable $= \frac{62 \cdot 5.Qh}{550}$ H.P.

With a well-designed Pelton wheel at full load, an efficiency of 85% may be expected; while with a well-designed needle valve nozzle the part load efficiency can be maintained at a remarkably high figure, governing being almost entirely on quantity, the nozzle velocity remaining nearly constant.

According to Gibson, "*Hydraulics and its Applications*," 1920, the Pelton wheel is by far the most suitable hydraulic prime mover for high heads, for powers in single units up to 2,000 b.h.p.

Two wheels are often mounted side by side on a single shaft, while two or three jets may be employed on a single wheel.

The Chute du Baton.

A typical high head Pelton wheel installation is the small power station at the Chute du Baton on a tributary of the Romanche,

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near Grenoble. The scheme was designed and executed by M. Ch-A. Keller, and incidentally employs the highest head utilised in France, viz.: 3,444 ft., and as such is deserving of description. The 6,600 h.p. is developed in two equal units, Pelton wheels, one of 8 ft. 6 in. diameter and 500 revs./min., and the other of 11 ft. 3 in. diameter and 375 revs./min. To each of the Peltons is coupled a 2,500 KVA alternator at 3,000/4,350 volts at 50 cycles. The pressure is transformed up to 26,000 volts for transmission. The intake works are at an altitude of 5,773 ft. The stream is here canalised, and the water is taken from the bed, so that a supply may be assured when the stream is covered with ice and snow. The water rushes into an underground tunnel, whence it is discharged into an underground settlement chamber, which can be flushed out when necessary, via a gallery specially constructed for this purpose; it then runs into a reservoir tunnel some 3,600 ft. long and 240 sq. ft. in section. The tunnel ends in a thick stopping wall, containing the inlet to the pipe line and an automatic throttle valve, which closes if the pipe line velocity exceeds the safe limit.

The twin pipe line itself is 5,133 ft. long and weighs over 400 tons. The upper half is constructed of riveted steel sections of thickness increasing from 3/16ths of an inch at the top, to nearly 1 inch at a depth of 1,650 ft. The lower half is of welded steel pipes of thickness varying from $\frac{5}{8}$ths of an inch to 1 1/16th inch at the bottom depth of over 3,400 ft. The diameter of each of the pipes is, for the upper half, 23$\frac{1}{2}$ inches, and for the lower half 17$\frac{1}{4}$ inches. The diameter at entry to the needle valve is 9$\frac{3}{4}$ inches, while the jet diameter is only about 2$\frac{1}{2}$ inches.

Governing is by the usual hydraulic relay regulator, and in addition if the wheel tends to run away, the spent water fails to clear the backs of the oncoming buckets, thus forming an automatic brake on the wheel.

The pipe line is buried 6 ft. below the surface of the ground to avoid freezing, the upper half by trenching, and the lower half by tunnelling, owing to the steepness of the slope—some 61 degrees.

An aerial ropeway was constructed to transport the pipes up the mountain side, the pipes being held in a cradle suspended by tackles from the travelling carriage, and capable of being lowered or raised at will. This ropeway has been left in position for maintenance purposes and to provide a ready means of communication from the valley to the headworks. The pipes forming the lower half of the pipe line were placed in position by hauling them one by one to the top of the tunnel, and lowering them down it.

The tunnel has a further object, namely the protection of the lower part of the pipe-line from the falls of rock that occur sufficiently frequently on the steep part of the mountain side. With this object also, the power station itself is hollowed out of the rock.

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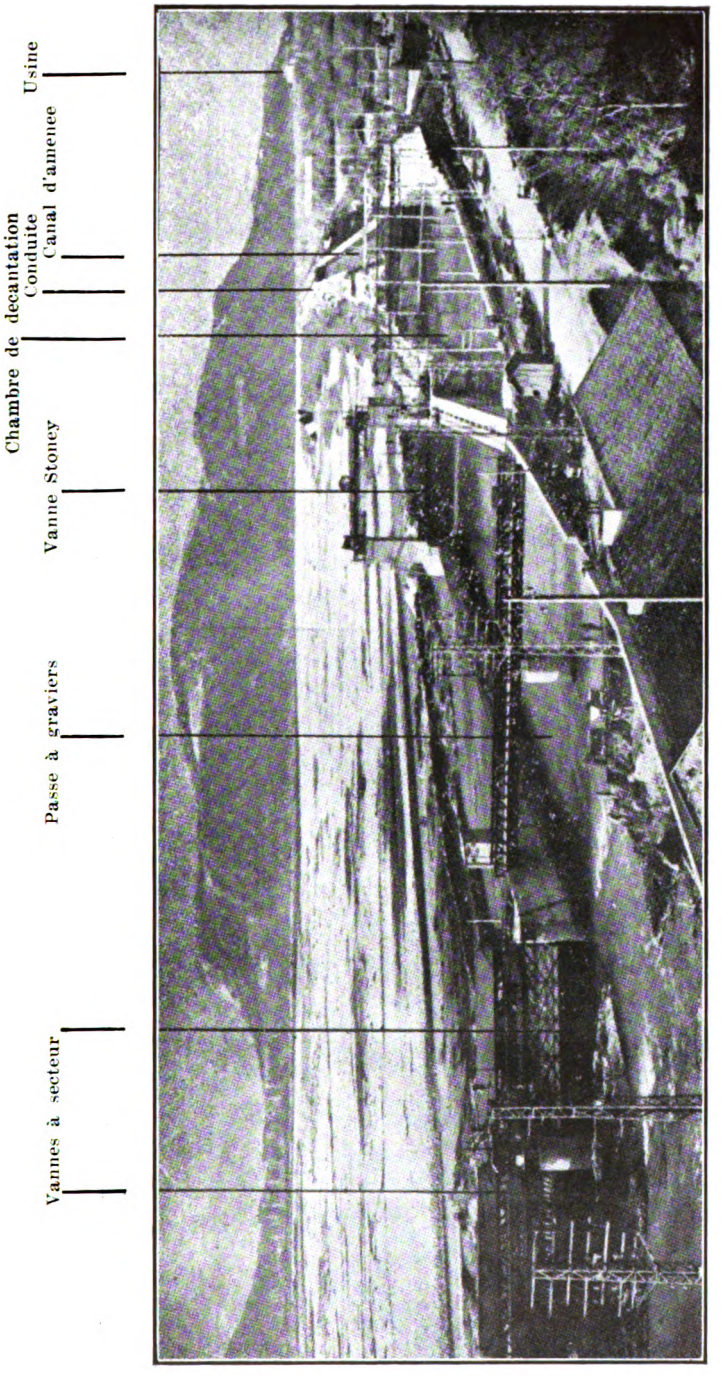

Fig. 7. **Vue Générale de L'installation Hydro-Électrique Drac-Romanche.**

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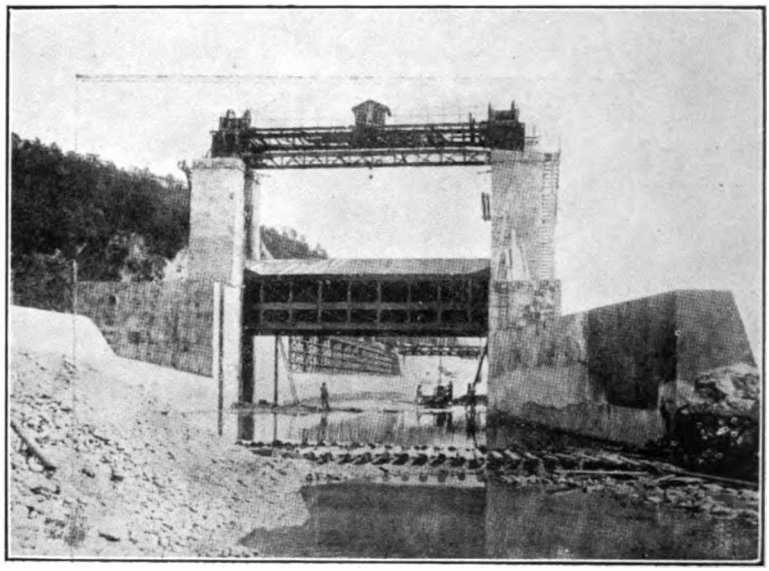

Fig. 8.

Prise d'eau, passe á graviers et vanne Stony.—Vue de l'aval.

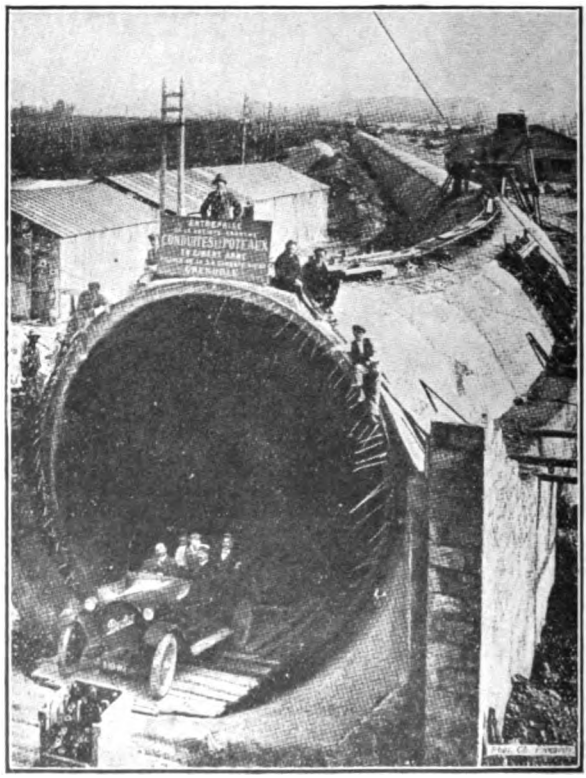

Fig. 9.

Conduite de Drac-Romanche

Diamétre : 6m00 — Longueur : 1600m.

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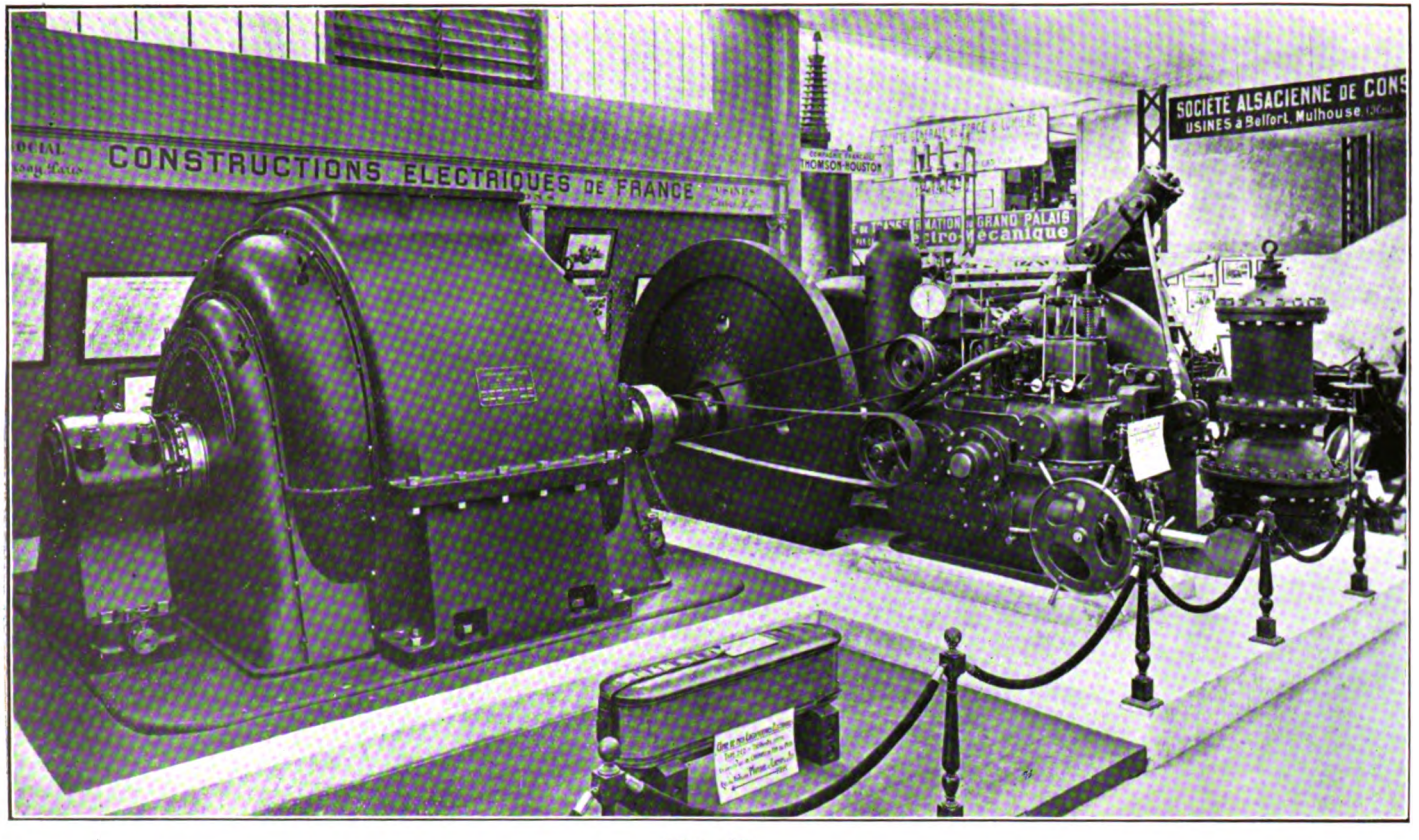

Fig. 12.

Grenoble Hydro - Electric Exhibition. Pelton-Wheel Unit, with Hydraulic Regulator.

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For safety, it is not placed directly at the foot of the pipe line, but a short way to one side. The pipe line tunnel is continued, however, after the pipes have turned off towards the power house, so that, in case of rupture, the water would be discharged clear of all buildings., Hydraulically operated pressure relief valves are placed at the foot of the pipe line. The only pipes entering the power station are actual connections to the needle valves of the two Pelton wheels. The tail race consists of twin channels leading to a gauging basin, whence a reinforced concrete conduit returns the water under low pressure to the bed of the stream. Fig. 1 shews the general arrangement of the works.

Type (*b*).

This type of development is suitable for high and medium heads, and is common in the region of the Pyrenees, where the existence of numerous high level lakes provides a solution of the problem of discharge regulation. It is also met with in the Alpine region. The constructional costs are, in general, greater per h.p. than in type (*a*). The pressure tunnel shewn in Fig. 2 may be replaced by an open channel approximately following the contours of the hillside, with the necessary slope to give the required discharge ; or a tunnel following the hydraulic gradient and ending in a water chamber with ample overflow weirs, may be constructed, as in the Eget scheme already mentioned. Here some 5½ miles of tunnel aqueduct have been constructed, bringing the waters from two systems of lakes to the head of the pipe line, whence a fall of over 2,400 ft. is obtained to the power station at Eget.

Type (*c*).—Where the natural slope of a watercourse is small, and the stream is confined between steep rocky banks, a comparatively small dam provides both a medium head and a considerable reservoir of water. The " Barrage reservoir " so formed is a type of development that is common in the region of the Massif Central. The dam is usually arch-shaped in plan, this type being particularly suited to short spans across narrow gorges with good rock abutments. The intake is by concrete lined tunnel from well behind the barrage. The tunnel ends in a solid obturating wall, beyond which is the valve-house, reached by an inclined gallery from the face of the rock, downstream of the barrage. The inlet level is generally some distance above the bottom level of the reservoir, on account of silt deposit. Thus, though the full head given by the barrage is available, the full storage cannot be utilised. From the valve house the water is led by pipe line to the power station, sited near the foot of the barrage at sufficient elevation to give a good tail race discharge. A part or the whole of the barrage may be used as a spillway to pass the flood waters.

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Type (d). Low head works.—Heads from 2 ft. up to about 100 ft. are classified as low heads, those from 100 ft. to 500 ft. as medium heads, and those above 500 ft. as high heads.

A high head, though as a rule economical, is by no means an essential to a satisfactory scheme. Where a large quantity of water is available continuously, large powers may be obtained with quite small heads. This means, however, an increase in the size of the turbines, the power station, and the head and tail race works. For example, in the Shannon scheme for the electrification of the whole of the Irish Free State a head of 100 ft. only is available, yet the discharge of the river is calculated to be sufficient to supply power to every dairy churn and chaff cutter in the country. Similarly, the spring tidal range in the Severn estuary is only some 42 ft., yet the day will doubtless come when this head will be economically turned to account to supply England and Wales with electric power.

Low head works do not, in general, admit of so much variation constructionally as the other types. They usually involve: a low barrage, or dam across the stream; the intake works, including trash-racks, settlement basin, head race canal and penstock forebay; the power station; and the tail race canal. The disposition and relative importance of these works depends on the conditions at the site.

Where the natural slope of the river bed is considerable, the necessary fall may be obtained with quite short head and tail race canals; while the fall around a long loop can often be utilised by cutting across the neck. (Fig. 5).

It is, however, frequently desirable to increase the natural head, and at the same time improve the discharge regulation, by constructing a low barrage across the stream. Where the barrage can be founded on rock it is usually constructed of masonry or concrete, otherwise an earthen dam with core wall is built. Timber crib dams are not common in France, but for very low heads with shingle river beds, barrages of gabions are largely employed, with a carefully constructed masonry or concrete spillway at one end. Above the fixed crest of the barrage the head can be further raised by a number of movable gates, which are automatically overturned in case of heavy floods.

A case in point is the barrage directly below the confluence of the Drac and the Romanche (Drac Romanche power station at Pont-de-Claix, near Grenoble), illustrated in Figures 7 to 11. The intake is on the right bank of the stream. The water passes first into a large gravel sluice closed at the downstream end by a Stoney lifting gate weighing 50 tons. Here the heavy gravels are deposited and can be sluiced clear to return to the river bed by a rapid hoisting of the Stoney gate. In the side of this gravel-sluicing basin are twelve orifices, protected by vertical trash-racks, through which the

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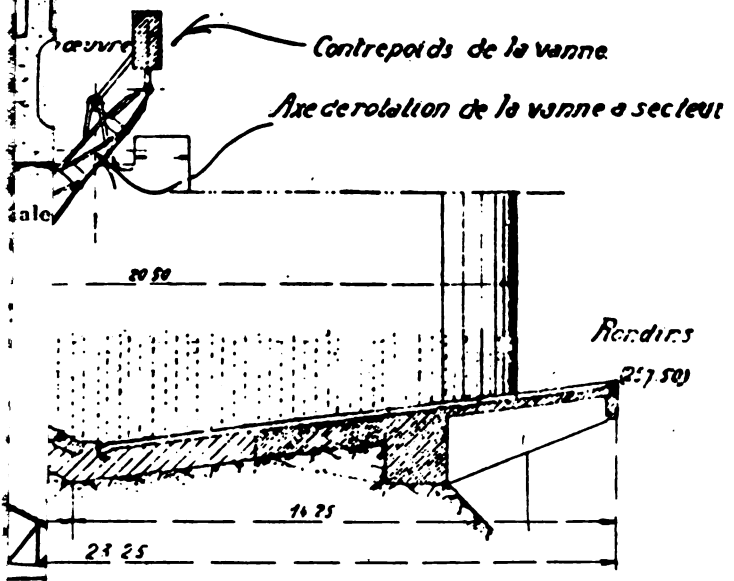
. 11.

OR GATE



vanne à secteur.

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water passes to the settlement basin proper. This can be cleaned out periodically by dredging. A short open channel leads from this basin to the reinforced concrete pressure conduit which claims to be the largest of its kind in the world, being nearly 20 ft. in diameter, and a mile long. The working head of water at the lower end is 50 ft. and here the conduit rises steeply with an increasing section to discharge the water into the open turbine forebay, which acts as a balance tank to protect the conduit and the turbines from the effects of water hammer. For this elevated forebay a considerable concrete structure was necessary, and alongside it is built the machine hall. The five turbines are of the back-to-back horizontal axis Francis type, with draught tube, developing 3,000 h.p. at 300 revs. per minute. An emplacement exists for the installation of a sixth turbine. Regulation is by compensated oil pressure servo-motor, operated by a centrifugal governor. The alternators and their exciters are mounted on the long horizontal turbine shaft, and an elevated control platform overlooks the machine hall. Three phase current at 5,500 volts and 50 cycles is delivered to the outside transforming station, whence it is fed at 26,000 volts by overhead line to the steelworks of MM. Bouchayer et Viallet (4,500 KVA.), and to the town of Grenoble for lighting. Underground cables at 5,500 volts feed the paper mills at Pont-de-Claix (1,500 KVA.), and the liquid chlorine factory (4,500 KVA.). The installation was completed in 1921, under the supervision of M. Pierre Ducrest, to whom the author is indebted for the permission to reproduce the illustrations referring to this work and the above particulars. The clear width of the flood gate openings is here, as elsewhere, laid down by the *Ministére des Travaux Publics*. To the left of the gravel sluicing basin are four sector gates, each of width 52 ft. 6 ins., and retaining a head of 10 ft. of water. These gates are carefully balanced so that they can each be raised by one man, with the aid of the winch.

The Economics of Water Power.

The commercial possibilities of water power depend mainly on the comparative costs of water power and any other kind of power that may be available for the area under consideration. With the increasing complexity of the coal problem, the future potentialities of water power become more and more assured. It is impossible to give any figures of general application as to the costs of water power, individual cases differing so widely. In general, however, large-scale developments are more economical per h.p. than small-scale ; and high head than low head schemes. The general tendency is towards the use of larger units for the prime movers, but in France little progress appears to have been made in this direction. Similarly, though in general it is more economical to harness the

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flow of a river with the minimum number of power stations, utilising the available fall in as large " slices " as possible, yet the first cost of the high head works involved when the natural slope of the river bed is small, the difficulty of raising capital and the fact that demands for power grow only gradually, have resulted in France in the installation of a large number of comparatively small power stations along the length of a river, the tail race waters of one discharging directly into the headworks of its downstream neighbour.

The costs of water power are almost entirely capital costs, namely, interest, sinking fund, depreciation, etc., The annual working costs are comparatively low.

Gibson (*Hydro-electric Engineering, Vol.* 1), gives the average constructional costs per installed turbine h.p. (exclusive of water-rights, land, transmission and distribution), on a pre-war basis, as

Canada	£14.2
Sweden	£11.7
Scotland..	£25

and states that the average costs for Canada and Sweden range from £27 for installations of less than 200 h.p. to £6.8 for an installation of 20,000 h.p.

The projectors of the Shannon scheme for the Irish Free State calculated the cost of production at ¼d. per unit.

The cost to the consumer is, of course, considerably increased by the cost of long-distance transmission.

In France constructional costs tend to be lower than in England on account of the lower basic wage rates and the lower cost of living, while in the Alpine region there is the further factor of the steady influx of Italian labour.

In conclusion, it may be noted that France stands second only to the North American continent for aggregate of hydro-electric horse-power installed, and in view of the numerous works actually under construction and projected, it would appear that she is making a determined bid for the leading place.

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MORE ABOUT OURSELVES.

By "PRAEFECTUS FABRUM."

"Oh, wad some Power the giftie gie us,
To see oursel's as others see us!"

Burns.

The poet's aspiration has never been fulfilled and never will be, but though we lack the gift in question we can have the next best thing to it. We can ask ourselves what are the qualities which others require of us, and how we can attain them.

In the interesting and thoughtful article which appeared in the last number of this Journal under the title of "Ourselves," the writer does, in fact, ask this question in another form. He says that we Sappers now and then discuss "that most interesting of all subjects—Ourselves—what we are, why we are what we are, whether we are what we ought to be, and if not, why not." In his lecture on "Engineers and the Army," General Thuillier spent some time in expounding why we are what we are, but the far more important question is whether we are what we ought to be.

What ought Royal Engineer Officers to be? For what purposes are they maintained by the State? Surely for no other purpose than to organise and superintend the engineering services required by the army *in war*. The Corps of Royal Engineers is not maintained in order to provide a soul-satisfying career for keen and ambitious young men. Do not those who dispute on the subject of the employment of our officers sometimes forget that service to the country in whatever line the country wants us is the real and high calling of every one of us? And the line in which she wants Royal Engineers is for the assistance they can give the rest of the army in war—nothing else.

It is unfortunate that the typical career described by Major Kerrich does not contain any war experience whatever. It no doubt happens sometimes that an officer goes through the whole of his service without being employed in war, but surely it cannot for any soldier be called typical.

He says that his typical specimen presents points of interest, "even if he has failed to strike out a line for himself, like the two officers who are now respectively Governor of Queensland and Permanent Under Secretary for the Colonies." Typical soldiers of any branch of the Army are not expected to strike out lines of that kind for themselves. Exceptional cases occur, of course, in every

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branch. An artillery officer became the first High Commissioner in Egypt, the cavalry can at this moment shew a Chancellor of the Exchequer and a Governor General of Canada. Another is a banker and was a member of the Coal Commission. But the system of training adopted for cavalry officers does not aim at fitting them for positions of this sort, and the training of engineer officers, though it does aim at producing a versatility which will render them adaptable to any work that confronts them, is nevertheless directed primarily at fitting them for their task in war. The question of specialism is one that puzzles a good many officers. It is undoubtedly, as Major Kerrich says, a relative term. On what all-round efficiency means he is not equally clear. He rightly shows that the military engineer cannot hope to become a specialist in the terms that would be understood in the civil engineering world. Nor is such a degree of specialism necessary. He does not, however, apply the same test to the definition given of the average all-round officer. Are not "first-class engineer and first-class soldier" also relative terms? What did the speaker whom he quotes mean by them? Did he mean that he should be as highly skilled in engineering as the best civil engineers of the day, and in soldiering as the most eminent and experienced soldiers? Obviously not; we all have a tendency to speak in superlatives, especially when decoyed into speaking in public. It is a little unkind to take a phrase without its context and hang an essay on it. Probably the speaker really meant "a thoroughly good engineer and a thoroughly good soldier."

Major Kerrich would have us abandon the idea that the average R.E. officer should be an all-round engineer. His reason is that this ideal is so high as to be discouraging. It certainly is if we tack on the qualifying epithet of "first-class" to it, and mean by it that he is to be practically a specialist in every branch of engineering. We are brought back to the necessity for defining what we mean by "first-class," and by "specialism."

The requirement for a regular military engineer, whose function, as I have said before, is to serve his country by organising and superintending the engineering services required by the army in war, is quite different from that of a civil engineer, whose aim in life is to make a competence—a fortune if possible—by the practice of civil engineering in peace. Modern developments force the latter to be a specialist, but the army does not require more than a few of its *regular* officers to be specialists. When it requires real specialists it can get them from civil life, but it requires from the majority of its regular engineers the capacity for dealing promptly and efficiently with the numerous minor engineering problems which arise in war, most of which are of a fairly simple nature. Above all, it requires from them the ability to improvise, to make

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the best use of limited, and often not very suitable, local resources. This requires a high standard of engineering training and a considerable all-round experience, both of which are incompatible with real specialism.

There is much similarity between the army's need of engineers and the ordinary citizen's need of doctors. Our everyday doctor is a " general practitioner." He can deal with the common colds, the children's whooping cough, measles etc., also with smallpox, typhoid, and all the normal everyday diseases, he can superintend the confinement of our wives and can also set broken limbs, treat wounds and accidents and perform minor surgical operations. But many cases arise when our general practitioner advises his patients to call in a specialist. The specialist may be required to diagnose obscure symptoms, to effect a special treatment, or to carry out an operation. The general practitioner does not pretend to be " first-class " at every branch of the medical and surgical arts, nor does the existence of numerous lines of specialism in the slightest degree lessen the necessity for " general practitioners." To divide the whole medical profession into specialists only and abolish the general practitioner would be most embarassing for the ordinary citizen, who when he had a pain would not know whether to send for his heart specialist or his stomach specialist. It would be more embarrassing still for the military commander when he wanted a bridge to find that his only engineer officer was a tunnel specialist. Or when he required a pumped water supply, to be told that the C.R.E. was only a construction specialist.

Major Kerrich proposes the adoption of the ideal of a " First-class Constructional (or Railway, Survey, or E. and M.) Engineer and First-class Soldier," instead of " First-class Engineer, etc." In other words he proposes a complete system of specialism. He bases this proposal on statistics of the peace employment of the officers of the Corps. But engineers are trained for war duties primarily, peace duties are quite secondary. Moreover statistics are notoriously dangerous things to quote from. It is said that they can be made to prove anything. From the table quoted by Major Kerrich it appears that—omitting the officers under instruction—the specialists, *i.e.*, E. and M., Railway and Survey officers, number 132 out of a total of 872, or 15 per cent. Those employed on " Works " are 302 out of 872, or 35 per cent. There is, however, no division at all between those employed on Works and those on Staff, Units, Military Schools and Miscellaneous. All these officers are interchangeable, even in peace.

Many of those now employed on Works and other duties have during their career in peace and war been employed (or will be), on Railway and Surveys, and the duties of Works officers often include E. and M. work of many kinds.

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Railway operation may be specialism, but Railway Construction is not; it is just ordinary engineering like any other. Every R.E. officer must be capable of carrying out surveys of the sites, often in undeveloped and tropical countries, of the engineering works, roads, etc., which he is going to construct. The mechanical and electrical requirements of the army in the theatre of war are getting greater every year. For the military engineer the various branches of engineering cannot be kept separate. A single job may embrace several of them, and all officers must be capable of interchange freely between the various kinds of work, according to whatever is the dominant need of the moment and the place. There is no parallel with civil life, and officers considering the question of their careers require to remember that they are soldiers, not merely engineers, and that they must look at the question from the point of view of what the army needs of them, and not only of what will best satisfy their personal tastes or ambitions. If the army mainly wants "general practitioners" their training should as far as practicable prepare them for this end. It is in no way an impossible ideal. If doctors can reach it so can engineers. Great numbers of military engineers have reached it in the past, and if it be said that engineering is more technical to-day than it was, it can also be said that the standard reached by the training of our young officers is higher.

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RAISING WATER FROM DEEP WELLS.

By MAJOR R. CHALMERS BLACK, R.E. (T.A.).

In the interesting Professional Note in the March issue of the Journal, details are given of a proposed method of pumping from deep wells, using a P.E. lorry to supply the power. Two sizes of pump are dealt with, of which the smaller is certainly within the capacity of the standard P.E. lorry. The larger (5½") pump would however, seem to call for more power than is ordinarily available from a P.E. lorry.

Assuming the usual efficiency (say 84%), the pump motor would take 330 amperes with 110 volts at the motor terminals. Allowing a 5-volt drop in the cable, the required output of dynamo and engine would be 38 kw. and 60 b.h.p. respectively. The pump water horse power is 22.7, showing an apparent efficiency of 57%, which includes all losses in pipes, valves and strainer. Whilst this efficiency can doubtless be attained on the test bed, it is doubtful if 50% would be exceeded in ordinary work from day to day. At 50% efficiency, the motor h.p. would be 45, equivalent to, say, 43 kw. and 68 b.h.p. at the dynamo and engine.

It is understood that the 'acceptance' figures for the P.E. lorry are 24 kw. and 50 b.h.p., from which it would appear that the 5½" pump would seriously overload the generating plant. The use of two P.E. lorries connected in parallel (or in series with a 220 volt motor) would seem to be impracticable on account of the peculiar field circuits employed on these lorries. It is for consideration however, whether an electrically driven pump is justified for use in the field and whether equally good results may not be attained at much less cost by driving the pump by means of a directly coupled petrol engine, the whole set being slung in the well as in the case of the motor driven pump. Certain difficulties present themselves in connection with operating an I.C. engine in such a position, but these difficulties are by no means insuperable. A suitable type of engine for this purpose would be that fitted to the 25 cwt. Morris lorry. This engine, which developes 35 b.h.p. at 2,000 r.p.m., measures about 2' 0" in length, over all, and, when coupled to the pump, the whole set should not exceed 3' 6" in length.

A special casting bolted to the flywheel casing would carry the pump casing, and totally enclose the coupling, which would conveniently be of the fabric disc type, connecting the engine clutch studs to a spider keyed to the pump shaft. A coil and distributer in place of the magneto would facilitate starting. A bye-pass on the rising main would furnish cooling water. The coupled set would be built into a cage or framing which would also carry the starter battery, the roof of the cage forming a platform from which the

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engine could be turned by hand, by means of a chain drive from the engine to the starting handle on the platform. Ordinarily the engine would be started by means of the self starter. As the drop in volts in the starter cable, if carried to the surface, would be prohibitive, some form of remote control for the starter switch would be essential. Probably a rope or wire from the switch to the well head would be all that would be necessary.

It is agreed that the duty would be a fairly arduous one for the engine, but as the cost of the engine (about £70 or £80) is moderate, and as it is made in quantity, frequent renewal would be less costly than the capital charges involved in having a P.E. lorry standing by driving an electrical pump. The weight of the engine-driven pump would be less than that of an electrical pump, whilst the consumption of petrol and oil would be at least 40% less.

The diameter of the well will, in general, restrict the choice to a 4-cylinder engine, which in turn will limit the power to something like 40 to 50 h.p. at 2,000 r.p.m. There are of course, 4-cylinder engines made capable of developing over 100 b.h.p., but this power is given off at 3,000 or 4,000 r.p.m.

If special circumstances make it necessary to use over 50 or 60 h.p. in a well of small diameter, the use of an engine of the radial type would be worth considering. An eleven-cylinder engine of this type having a bore and stroke of 80 x 125 mm. should develop over 100 b.h.p. when run at 2,000 r.p.m., the extreme diameter over the cylinder heads not exceeding 3′ 6″.

This type of engine has been developed considerably, chiefly as an air cooled unit, for aeroplane work, but, doubtless, a water cooled set could be built mainly from standard engine parts, and which would provide the maximum power within the limitations of space. It is probable, however, that the type of engine fitted to the 30-cwt. subsidy lorry would provide sufficient power for the very large majority of wells. It is, of course, most desirable to use an engine of which large supplies are available and which can be readily adapted for use with the minimum of alteration and special parts.

Placing the motor, of whatever kind, at the water level introduces certain complications, and as inspection is difficult, the plant is likely to suffer from neglect. For this reason, the bore-hole type of centrifugal pump, in which the power is transmitted to the pump by means of shafting passing down through the rising main, would seem to merit serious consideration as a pump for semi-portable use in the field. An interesting form, made by Messrs. Mirrlees, Watson and Co., Ltd., Glasgow, has shaft bearings of rubber, lubricated by the water in the rising main.

This type of pump, suitably modified for use in the field, would seem to be preferable in all respects to any form of pump having the driving motor at, or near, water level.

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THE RELATION BETWEEN DECKING AND ROADBEARERS IN MILITARY BRIDGES.

By CAPT. H. A. BAKER, M.C., R.E.

Judging by the information obtainable from the various military text books this is a subject that has not received the consideration it deserves. It is, however, one of great importance to the military engineer when designing bridges for heavy military loads.

In civilian practice there are certain rules which lay down a definite relationship between the stringers and the flooring for highway bridges for various classes of load. In designing military bridges the problem is closely analogous to that of the civilian bridge if an R.S.J. bridge is compared to the span between the cross girders of a girder bridge. There are to be found in certain text books tables giving the spacing of joists and the thickness of decking for various classes of load. These allow for a concentrated wheel load with or without the addition of a distributed load on the remainder of the bridge. Unfortunately, these tables are worked out for different classes of loading, and although useful for comparison do not give the actual figures required.

Military bridges are almost invariably designed for single line traffic, and the problem, therefore, has to be worked out for a single axle load in various positions.

It is laid down that bridges for mechanical transport should be 10′ wide between wheelguides, and that not less than 8′ is required for infantry in fours. A 3-ton lorry with a wheel track of 6′ 7″ can thus wander 3′ 5″ from either wheelguide. This brings up the problem of the number of roadbearers and the thickness of decking required. If, in a particular case, the number of roadbearers required to resist the Maximum Bending Moment were calculated in the usual way, it might be found that perhaps 4 or 5 were required. Considering the arrangement of these, if only two were placed under each wheel, the decking would have to be very thick to distribute the load sufficiently evenly to both roadbearers with the lorry in the most eccentric position.

In practice it will usually be found necessary to increase the number of roadbearers found by calculation, and to provide decking stiff enough to ensure that no roadbearer is overstressed under the worst conditions.

There is an alternative when material is scarce, which consists in cutting down the width of the roadway to, say, 8′, and grouping the roadbearers directly under the wheels. In this case

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the decking can be quite small provided it is strong enough to carry Infantry in fours, horses, etc., which may come between the roadbearers. It is desirable to provide a footwalk alongside, so that individuals can cross the bridge while wheel traffic is on it. It will be necessary to provide very strong wheelguides, and to arrange them at the approaches so that vehicles cannot get on the wrong part of the bridge. The disadvantage of this method is that traffic is slowed up considerably in crossing the bridge, which is not desirable.

Let us take an example, and investigate the ways in which roadbearers and decking may fail.

Suppose by calculation for Mff. it is found that two R.S.J.'s are required to support each wheel of a vehicle.

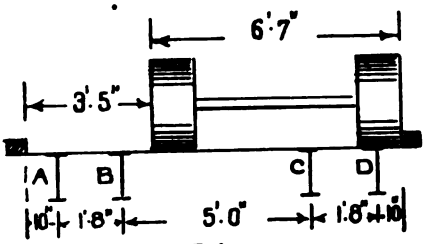

FIG. 1.

Referring to Fig. 1, the R.S.J.'s might be arranged as shown. With the vehicle in this position what are the proportions of load borne by the joists and what is the Maximum Bending Moment and shear in the decking? It will be quite evident from an inspection of the figure that joist D is bearing a large proportion of the load. If it is only capable of taking half a wheel-load, it will be considerably overstressed. The decking is also subjected to a large bending moment in distributing the load to the joists. It is clear that this arrangement is unsuitable unless the joists are strong enough to carry the proportion of the load that comes on them in this position of the load, or the decking is stiff enough to distribute nearly half a wheel-load to joists A and C. To effect this the decking would have to be so thick as to be quite impracticable.

The decking may also fail by Bending Moment in the position shown in Fig. 2, or shear in the position shown in Fig. 3.

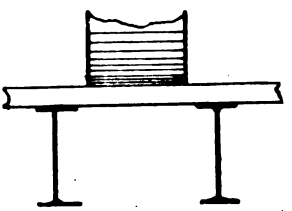

FIG. 2.

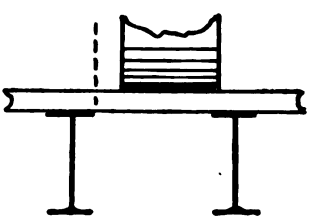

FIG. 3.

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The calculation of the actual percentage of wheel-load borne by any one joist is of a complicated nature, depending on deflections, and is quite impracticable in the field. The object of this paper is to deduce from calculations and practical tests some standard methods of arranging roadbearers which will be useful as a guide in designing bridges for military loads.

It is proposed, therefore, to work through one example by calculation to show the method in which the table on page 484 has been compiled. The references in the table to practical tests refer to tests carried out at Christchurch and Chatham, and the figures will be seen to bear out the theory fairly well. The differences are due to the following causes :—

1. Firmly fixed ribands tend to distribute the load through the decking.

2. Timber is an unreliable material and the Modulus of Elasticity varies considerably in each piece. The figure chosen is an average one.

3. Although a timber beam may begin to shear along the grain this may not cause immediate failure ; this is due to the fact that timber is an unhomogeneous material ; its strength in shear along the grain is much less than in shear across the grain. The effect is that, although it may begin to split at the ends where shear is greatest, this does not reduce the section to resist vertical shear. It does reduce the resistance to bending, but the point of maximum shear does not coincide with the point of maximum bending moment except in the case of a cantilever. Hence, if the split does not go too far, the beam may still be able to support the load if it has been correctly designed for Bending Moment. It will thus be seen that, provided the figures for vertical shear and for bending are not exceeded, the beam will probably be safe enough for this class of work. Experience is valuable in such cases and in applying theory to practical design it must be used to aid the designer. If a piece of decking does crack badly it can easily be replaced.

Example.—Calculate the maximum percentage of a wheel-load borne by any one joist and the Bending Moment and Shear in the decking for conditions shown in Fig. 4.

It will be evident that the maximum percentage borne by one joist will occur in the position shown in Fig. 4. The example is, therefore, worked out for this position of the load. The arrangement shown is that chosen for the old stock spans of 21′ 6″ and 30′. No

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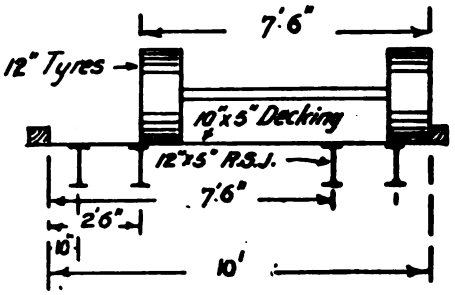

FIG. 4.

practical figures are available for this case, but the example with 5 joists is too complicated to include here. The results are, however, shown in the table. The calculation is worked out in more or less general terms as in Fig. 5 and the figures for a particular case inserted afterwards.

This arrangement will bring maximum stress into the joist S.

The following data are known in addition to those shown on Fig. 5.

Span of joists	$=a$
Modulus of Elasticity for joists	$=E_1$
,, ,, for decking ..	$=E$
Moment of Inertia joists	$=I_1$
,, ,, decking..	$=I$

The only departure from a general case is that, to save endless figures, it is assumed that the axle is in the position shown against one wheelguide and that l_1 is less than b, which is less than l_2 and that $b + c$ is greater than l_3.

Now if P, Q, R, S, are the reactions of the respective R. S. J., and δ_1, δ_2, δ_3, δ_4 the deflections at these points as loaded in Fig. 5.

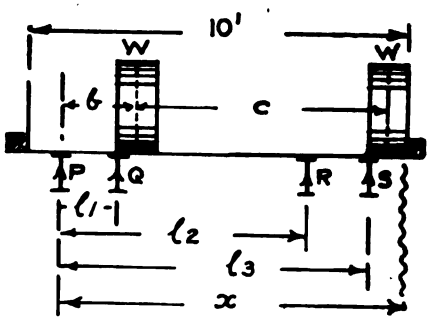

FIG. 5.

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Then from Statics,

$$P + Q + R + S = 2W \quad \ldots\ldots (1)$$

$$Ql_1 + Rl_2 + Sl_3 = W(2b + c) \quad \ldots\ldots (2)$$

Then the B.M. in the decking at any point x measured from P $= Mx = -\dfrac{EId^2y}{dx^2}$

and hence $\dfrac{-EId^2y}{dx^2} = Px + Q(x-l_1) + R(x-l_2) + S(x-l_3) - W(x-b) - W(x-b-c) \quad \ldots (3)$

The terms in brackets are to be neglected when negative and integration is to be made with respect to $(x - l_1)$; $(x - l_2)$, etc.

Then integrating both sides of equation (3) we get

$$-EI\frac{dy}{dx} = \frac{Px^2}{2} + \frac{Q}{2}(x-l_1)^2 + \frac{R}{2}(x-l_2)^2 + \frac{S}{2}(x-l_3)^2 - \frac{W}{2}(x-b)^2 - \frac{W}{2}(x-b-c)^2 + A$$

and

$$-EIy = \frac{Px^3}{6} + \frac{Q}{6}(x-l_1)^3 + \frac{R}{6}(x-l_2)^3 + \frac{S}{6}(x-l_3)^3 - \frac{W}{6}(x-b)^3 - \frac{W}{6}(x-b-c)^3 + Ax + B \quad (4)$$

Now the deflection of a joist length a under a load P at the centre is $\dfrac{a^3}{48E_1I_1}P = d_1$

Therefore $-EId_1 = \dfrac{-a^3EIP}{48E_1I_1} = B$ (substituting $x = o$ in (4)) $\ldots\ldots (5)$

Similarly $-EId_2 = \dfrac{-a^3EIQ}{48E_1I_1} = \dfrac{Pl_1^3}{6} + Al_1 + B$ (substituting $x = l_1$ in (4)) (6)

and $-EId_3 = \dfrac{-a^3EIR}{48E_1I_1} = \dfrac{Pl_2^3}{6} + \dfrac{Q}{6}(l_2-l_1)^3 - \dfrac{W}{6}(l_2-b)^3 + Al_2 + B$ (7)

and $-EId_4 = \dfrac{-a^3EIS}{48E_1I_1} = \dfrac{Pl_3^3}{6} + \dfrac{Q}{6}(l_3-l_1)^3 + \dfrac{R}{6}(l_3-l_2)^3 - \dfrac{W}{6}(l_3-b)^3 + Al_3 + B$ (8)

For simplicity write $\dfrac{a^3EI}{48E_1I_1} = F$

Then substituting in (6) for B we get $FQ + \dfrac{Pl_1^3}{6} + Al_1 - FP = o$

whence $A = \dfrac{P}{l_1}\left(F - \dfrac{l_1^3}{6}\right) - \dfrac{FQ}{l_1} \quad \ldots\ldots (9)$

Substituting for A and B in (7) and (8) we get

For (7) $FR + \dfrac{Pl_2^3}{6} + \dfrac{Q}{6}(l_2-l_1)^3 - \dfrac{W}{6}(l_2-b)^3 + \dfrac{Pl_2}{l_1}\left(F - \dfrac{l_1^3}{6}\right) - \dfrac{Fl_2}{l_1}Q - FP = o$

and collecting terms

$$FR + P\left\{\frac{l_2^3}{6} + \frac{l_2}{l_1}\left(F - \frac{l_1^3}{6}\right) - F\right\} + Q\left\{\frac{(l_2-l_1)^3}{6} - \frac{Fl_2}{l_1}\right\} - \frac{W}{6}(l_2-b)^3 = o$$

For simplicity write $\left\{\dfrac{l_2^3}{6} + \dfrac{l_2}{l_1}\left(F - \dfrac{l_1^3}{6}\right) - F\right\} = V$

$$\frac{(l_2-l_1)^3}{6} - \frac{Fl_2}{l_1} = X$$

$$\frac{(l_2-b)^3}{6} = Y$$

Then $FR + VP + XQ - YW = o \quad \ldots\ldots (10)$

and for (8)

$$FS + P\left\{\frac{l_3^3}{6} + \frac{l_3}{l_1}\left(F - \frac{l_1^3}{6}\right) - F\right\} + Q\left\{\frac{(l_3-l_1)^3}{6} - F\frac{l_3}{l_1}\right\} + \frac{R}{6}(l_3-l_2)^3 - \frac{W}{6}(l_3-b)^3 = o$$

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For simplicity write $\left\{\frac{l_2^3}{6}+\frac{l_2}{l_1}(F-\frac{l_1^3}{6})-F\right\}=Z$

$$\frac{(l_3-l_1)^3}{6}-\frac{Fl_3}{l_1}=H$$

$$\frac{(l_3-l_2)^3}{6}=K$$

$$\frac{(l_3-b)^3}{6}=M$$

Then $FS+ZP+HQ+KR-MW=0$ .....(11)

Now from (1) $P=2W-Q-R-S$

and from (2) $Q=\frac{W(2b+c)}{l_1}-\frac{Rl_2}{l_1}-\frac{Sl_3}{l_1}$ .....(12)

Hence $P=W(2-\frac{(2b+c)}{l_1})+R(\frac{l_2}{l_1}-1)+S(\frac{l_3}{l_1}-1)$ .....(13)

Substitute for P and Q in (10) and (11). (10) becomes

$$FR+VW(2-\frac{2b+c}{l_1})+VR(\frac{l_2}{l_1}-1)+VS(\frac{l_3}{l_1}-1)+XW\frac{(2b+c)}{l_1}-\frac{XRl_2}{l_1}-\frac{XSl_3}{l_1}-YW=0$$

$$\text{or } R\left\{F+V(\frac{l_2}{l_1}-1)-\frac{Xl_2}{l_1}\right\}+S\left\{V(\frac{l_3}{l_1}-1)-\frac{Xl_3}{l_1}\right\}+W\left\{V(2-\frac{2b+c}{l_1})+X\frac{2b+c}{l_1}-Y\right\}=0$$

Writing $F+V(\frac{l_2}{l_1}-1)-\frac{Xl_2}{l_1}=\alpha$

$$V(\frac{l_3}{l_1}-1)-\frac{Xl_3}{l_1}=\beta$$

$$V(2-\frac{2b+c}{l_1})+X\frac{2b+c}{l_1}-Y=\Delta$$

This becomes $\alpha R+\beta S+\Delta W=0$ .....(14)

(11) becomes

$$FS+2W(2-\frac{2b+c}{l_1})+ZR(\frac{l_2}{l_1}-1)+ZS(\frac{l_3}{l_1}-1)+HW\frac{2b+c}{l_1}-\frac{HRl_2}{l_1}-\frac{HSl_3}{l_1}+KR-MW=0$$

$$\text{or } R\left\{Z(\frac{l_2}{l_1}-1)-\frac{Hl_2}{l_1}+K\right\}+S\left\{F+Z(\frac{l_3}{l_1}-1)-\frac{Hl_3}{l_1}\right\}+W\left\{Z(2-\frac{2b+c}{l_1})+H\frac{2b+c}{l_1}-M\right\}=0$$

Writing $\left\{Z(\frac{l_2}{l_1}-1)-\frac{Hl_2}{l_1}+K\right\}=\theta$

$$F+Z(\frac{l_3}{l_1}-1)-\frac{Hl_3}{l_1}=\varphi$$

$$Z(2-\frac{2b+c}{l_1})+H\frac{2b+c}{l_1}-M=\rho$$

This becomes $\theta R+\varphi S+\rho W=0$ .....(15)

Solving (14) and (15) for R

$$R(\alpha\varphi-\theta\beta)+W(\Delta\varphi-\rho\beta)=0$$

or $$R=-\frac{(\Delta\varphi-\rho\beta)}{\alpha\varphi-\theta\beta}W$$ .....(16)

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and solving for S

$$S = -\frac{(\triangle\theta - \rho\alpha)}{\beta\theta - \alpha\varphi} W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

and P and Q can be found by substitution in (1) and (2).

The particular case under consideration can now be taken. It is not proposed to show the working as it is too laborious. It is merely a matter of substituting figures for the various symbols taken. The arrangements are as in Fig. 4. The decking is 10" x 5" and the R. S. J's are 12" x 5".

The various data then become.

a = 21′=252"
I_1 = 220.175 Ins.⁴
E_1=13400 In. tons units.
I = 104.17 Ins.⁴
E = 811 In. tons units.
l_1 = 20 in.
l_2 = 80 in.
l_3 = 100 in.
b = 26 in.
c = 78 in.

By substitution in the above formula

P = 20.8% W
Q = 48.7% W
R = 51.3% W
S = 79.2% W

For the purpose of finding the maximum percentage of wheel-load to be borne by the joist S with varying spans, decking and joists, but for the same arrangement of joists and the same wheel-track, the formula can be reduced to

$$S = \frac{52F^2 + 0.4831 \times 10^6 F + 986.8 \times 10^6}{68F^2 + 0.6187 \times 10^6 F + 880 \times 10^6} \times W$$

The value of F being $\frac{a^3 EI}{48E_1 I_1}$

Bending Moments in Decking.

The Maximum Bending Moment in the decking can now be determined by substituting for P, Q, R, and S, in equation (3) for Bending Moment previously found. Shear can be written down at once, P, Q, R, and S being known.

The results so obtained are shown in the graph.

From this it will be seen that *Mff* is 8.33 W, and the Maximum Shear is 0.305 W for the wheel in this position.

Assuming these are the maximum figures arising from this consideration, the Bending Moment and Shear in the decking when a wheel is directly between two joists should now be calculated (Fig. 6).

This is determined as follows.

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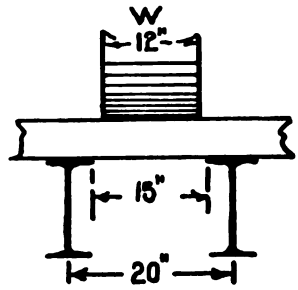

FIG. 6.

Assuming the unsupported length of decking is 15 in. (between edges of flanges), and assuming a 12 in. wheel centrally placed.

$$\text{B.M.} = \frac{W}{2} \times \frac{15}{2} - \frac{W}{2} \times 3 = \frac{9}{4} W = 2.25\ W.\ \text{In. tons.}$$

The shear should be calculated with the load as in Fig. 7, with the

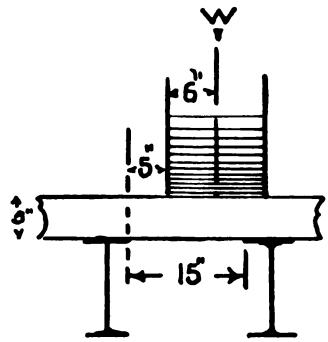

FIG. 7.

edge of the wheel a distance equal to the thickness of the decking from the edge of the flange. If it is any nearer, the decking is found in practice not to shear, owing to the distributive effect of the fibres.

Assuming 5" decking, shear will be seen to be negligible as this arrangement brings the edge of the wheel directly over a joist.

If the vehicle under consideration has narrow tyres this may be the deciding factor.

Referring to the B.M and shear diagram :—

The Maximum Shear is taken where a 12" wheel is not directly over any part of a joist. The shear diagram is made for a concentrated load, but with a 12" wheel it is obvious that the wheel will relieve the decking of shear if any part of it is over a joist. The maximum shear taken is, therefore, 0.305 W, not W.

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Now find what W can be with the 10 in. × 5 in. decking chosen. M_r of 10 in. × 5 in decking, assuming pitch pine $= \frac{1}{6}rbd^2 = \frac{1}{6} \times \frac{3}{4} \times 10 \times 25 = 31.4$ In. tons.

$$Mf = 8.33W \text{ In. tons from graph.}$$

$$\text{Hence } W = \frac{31.4}{8.33} = 3.73 \text{ tons approximately.}$$

And the axle load can be 7.5 tons.

$$\text{Resistance to shear along the grain} = \frac{10 \times 5 \times 150}{2240} = 3.36 \text{ tons.}$$

$$\text{Maximum shear} = 0.305\,W \text{ from graph.}$$

$$\text{Hence } W \text{ can be } \frac{3.36}{0.305} \times \frac{2}{3} = 7.35 \text{ tons.}$$

or an axle load of 14.7 tons.

A joist has to take 0.792W in the worst case + a proportion of the dead load. The weight of one joist and a proportion of the decking is 1672 lbs.

$$\text{Hence the B.M. on a joist is } \frac{0.792W \times 21 \times 12}{4} + \frac{1672 \times 21 \times 12}{8 \times 2240} \text{ In. tons}$$

$$\therefore \text{Section Modulus required is } \frac{0.792W \times 21 \times 12}{4 \times 7.5} + \frac{1672 \times 21 \times 12}{8 \times 2240 \times 7.5} \text{ Ins.}^3$$

The Section Modulus of one 12 in. × 5 in. joist is 36.66 Ins.^{3}

$$\text{Hence } W = \left(36.66 - \frac{1672 \times 21 \times 12}{8 \times 2240 \times 7.5}\right) \frac{4 \times 7.5}{0.792 \times 21 \times 12} = 5 \text{ tons.}$$

Allowing for an Impact factor of 50%, W = $3\frac{1}{3}$ tons.
or an axle load of $6\frac{2}{3}$ tons.

It will thus be seen that the joists are the deciding factor but that decking and joists are of nearly equal strength. The bridge, therefore, is suitable for Medium Loads ($5\frac{1}{2}$ ton axle).

The Maximum Axle according to the calculations is $6\frac{2}{3}$ tons, but this arrangement would be safe for 8 ton axles (Fodens) in practice. The factor of safety throughout is 4, and, as the load is unlikely to be in this extreme position frequently, there is little risk in reducing the factor of safety to 3.65 for this contingency.

It will be noticed that no Impact Factor is included for the decking. In practice, if a lorry is moving at a speed sufficient to produce Impact, the load on any one piece of decking will only be of very short duration, and it is safe to neglect impact in temporary work.

In calculating decking it has been found from experiments that the figures for Group I timber can be taken with safety for any good class building timber, as the conditions met with in practice modify the factors assumed in calculation and tend to make calculated results very much on the safe side if the smaller figures are used.

As an instance of the importance of this calculation a case from the last war may be of interest. A certain bridge in France decked with ordinary $1\frac{1}{2}$" chesses was crossed by a pontoon wagon well loaded with souvenirs and baggage. The result was that every single chess was broken as the wagon crossed, just holding the load long enough to let the wheel get on to the next chess without going through.

The above results show how important it is to provide decking sufficiently stiff to distribute the load to the joists in the bridge,

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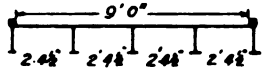
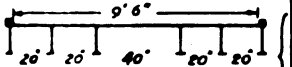
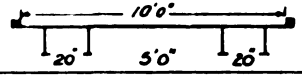
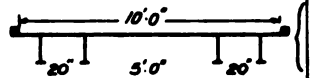
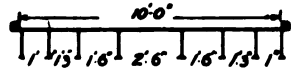
TABLE SHOWING SIZE OF DECKING & NUMBER & SIZE OF ROADBEARERS SUITABLE FOR VARIOUS SPANS & CLASSES OF LOADING

LOADING	DISTANCE BETWEEN WHEEL GUIDES	SIZE OF DECKING	CLEAR SPAN	ARRANGEMENT OF ROADBEARERS	SUITABLE SIZE OF R.S.J.	MAX % OF AXLELD BORNE BY ONE JOIST(APPX)	REMARKS.
Two Ton Axles	9' 0"	12"x 1½"	9'		5"x3"	42	Percentages approximate, and derived from calculation and practical tests on similar types of bridge. 3" Decking would reduce this to about 30%.
" "	9' 0"	12"x 1½"	15'	do	8"x4"	40	
Medium 5½ Ton Axles	9' 6"	9"x 3"	20'		9"x4"	25	% Deduced from practical tests supported by calculation. Tests with double 12"x 1½" decking & N° 7-6'3" N.C Joists equally spaced over 21' span gave 22.8%.
" "	9' 6"	9"x 3"	26'	do	10"x 4½"	26	
Medium 5½ Ton Axles	10'	10"x 3"	24'		12"x 5"	40	Calculated.
Heavy 16 Ton axles	10'	10"x 3"	24'		18"x 6"	41	Calculated with 16 Ton axle on 7' wheel track the factor of safety is rather low when in the extreme position. (Similar to old 30' Stock spans which took 35 Ton Tanks up to 30' with 18"x 7" joists.
		10"x 4"	29'		20"x 6½"		
Ditto	10'	10"x 3" or 9"x 4"	20'		12"x 5"	18	Calculated approximately by analogy.

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and show that it is not sufficient to calculate the number of joists required to carry the load, assuming each to take an equal share, if the load is allowed to wander about the bridge.

With smaller loads, where the tyres are narrower than 12", the deciding factor may be shear when the wheel is between two joists.

It is manifestly impracticable for anyone to sit down and make calculations of this nature in the field. It is hoped that this paper has shown the necessity for some guiding principles or rules in designing decking. The table opposite has been compiled partly from practice and partly from theoretical calculations, and shows suitable combinations of decking and joists in most of the cases likely to be met with. The percentage borne by each joist in the worst conditions is approximate only, and in some cases arrived at by interpolation, as the calculations are too laborious. These arrangements can be modified to suit other conditions provided that the principles involved are understood.

The author is indebted to Mr. J. W. Landon, M.A., for assistance with the theory on which these examples have been worked out.

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MODERN PRACTICE IN E. AND M. ENGINEERING.

II.

MERCURY ARC RECTIFIERS.

By LIEUT. K. H. TUSON, R.E.

Owing to their lack of rotating parts and high efficiency, mercury arc rectifiers are coming and will come more and more into use for the conversion of alternating to direct current.

When an arc is struck between any two electrodes ionisation commences, and the current in the arc may be said to consist of a stream of electrons passing from the cathode to the anode.

To expel these electrons a certain minimum electromotive force is necessary, and a voltage drop occurs at the cathode. This e.m.f., known as the ionisation potential, depends on the material and temperature of the cathode and the degree of vacuum in which the arc takes place.

At atmospheric pressure and ordinary temperatures the ionisation potential for most materials is relatively small, but at low pressures it is considerable. Below about half a millimetre of mercury it is several thousand volts for a cold iron or carbon cathode, and only in the neighbourhood of six for mercury.

When an alternating pressure is applied between mercury and, say, carbon electrodes in an exhausted vessel, and an arc is struck, electrons are repelled from the mercury when it is at a negative potential, and attracted by the positive carbon. At the same time the comparatively massive mercury atoms, each minus an electron and consequently positively charged, are attracted back into the mercury, and their bombardment keeps it at a high temperature. The carbon electrode, being only bombarded by the light electrons (which weigh only 1/36,000 the positively charged atoms of mercury and have not a relatively greater velocity) remains cold, and will not emit electrons or function as a cathode.

Directly the carbon electrode gets hot (over 2,000 degrees) it will emit electrons and the valve action will cease.

With the arrangement shown in Fig. 1, a pulsating unidirectional current will flow, as in Fig. 1a. By using two anodes, and feeding the bulb as shown in Fig. 2, both halves of the a.c. wave can be utilised, but a break will occur twice in every cycle, as can be seen from Fig. 2a. This is due to the fact that the sinusoidal a.c. pressure drops below the minimum necessary to maintain the arc (about 15 volts) twice in every period.

A three-phase supply will be seen from Figs. 3 and 3a to give a unidirectional d.c. current without breaks, but a ripple is still present. The greater the number of phases, the smaller will this ripple be, one anode being necessary for each phase employed.

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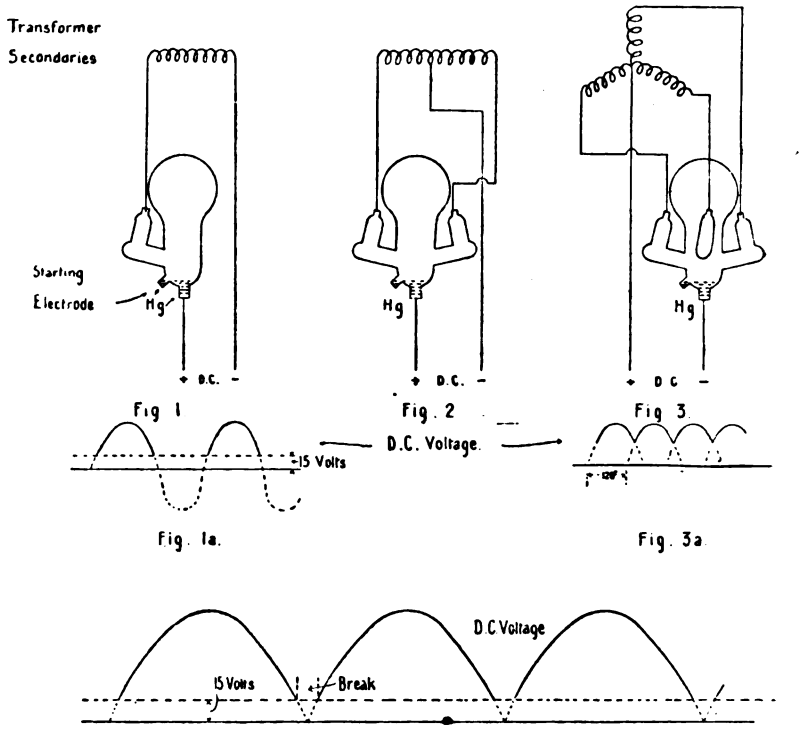

Figure 2a.

There is a constant relation between the a.c. and d.c. voltages, depending on the number of phases. Where this is three, the relation is $E_a = 1.6\ E_c + 24$, E_a and E_c being the a.c. and d.c. voltages respectively. The voltage drop in the bulb is from 15 to 20 volts, and decreases slightly after the bulb has been in use some time and the vacuum improves. For single phase circuits the relation is $E_a = 2.37\ E_c + 30$.

There are two main types of power rectifiers. For large outputs the arc is arranged to take place in a steel tank, and is usually supplied with six-phase current. Two stage vacuum pumps to maintain the vacuum have to be run continuously on all but light loads, thus introducing the complication of rotating machinery. Glass bulbs can be used for currents up to 200 amperes, and for outputs up to 1,000 kw. banks of these in parallel can be used. With these the whole apparatus is enclosed in cubicles with the switch controls in front, as can be seen from Figure 5. Most of the rest of this paper may be read as referring to these glass bulb rectifiers, the most useful type for military purposes.

Unfortunately a great number of elaborations are required before the simple theory can be put into practice. In the single phase circuit previously outlined the direct current passes through zero twice in every cycle, when the arc will extinguish and not

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relight. (It can be seen from figures 1a and 2a that the current does not only have an instantaneous zero value, but that there is a definite break from the moment at which the a.c. voltage falls below that necessary to maintain the arc—about 15 volts—to the moment at which it rises to this value again.)

To avoid this, an inductance must be placed in each anode circuit to choke back the falling current and keep the arc alight.* In a three-phase rectifier inductances are not necessary for this purpose, but they are found to be essential to secure an equal distribution of load among bulbs running in parallel. These inductances, of course, reduce the rectifier power factor. Then a choking coil must be placed in the d.c. circuit, as, however great the number of phases, there would always be too big a ripple without it for practical purposes.

In steel cased rectifiers an auxiliary anode is pulled into contact with the cathode to start the arc. Until very recently d.c. was necessary, and had to be provided for this purpose, but now a.c. can be used—a great advance.

Some arrangement must be made for starting the arc. This is done in the glass bulb type by tilting the bulb until the pool of mercury forming the cathode comes into contact with a pool forming an auxiliary anode. It is found also that the arc will not keep alight on low loads, and auxiliary anodes, making the equivalent of a small single phase rectifier and complete with inductances, have to be put in.

A fan is provided to blow air over the bulb for cooling purposes. When the anodes get hot enough for electronic emission the arc loses its usual property, and conducts in both directions, with the result that a "flash-over" occurs and the anode fuses blow. (As a matter of fact, flash-overs act as a safety valve and prevent bulbs breaking).

The best and most common method of providing voltage regulation is to connect an auto-transformer with tappings between the main transformer and the bulb. For traction loads this is unnecessary, as the inherent regulation of the bulb (about 7%) is sufficiently good. In automatic gear a small induction motor, controlled by voltage relays, works the tapping switches on the rectifier panels (see Fig. 5).

For all but very small outputs bulbs are used in pairs, connected in one of two ways:—

(*a*) The main transformer has a three-phase star-connected secondary winding supplying the regulating transformer, which supplies both bulbs in parallel.

(*b*) The main transformer has two secondary windings with

* See Appendix.

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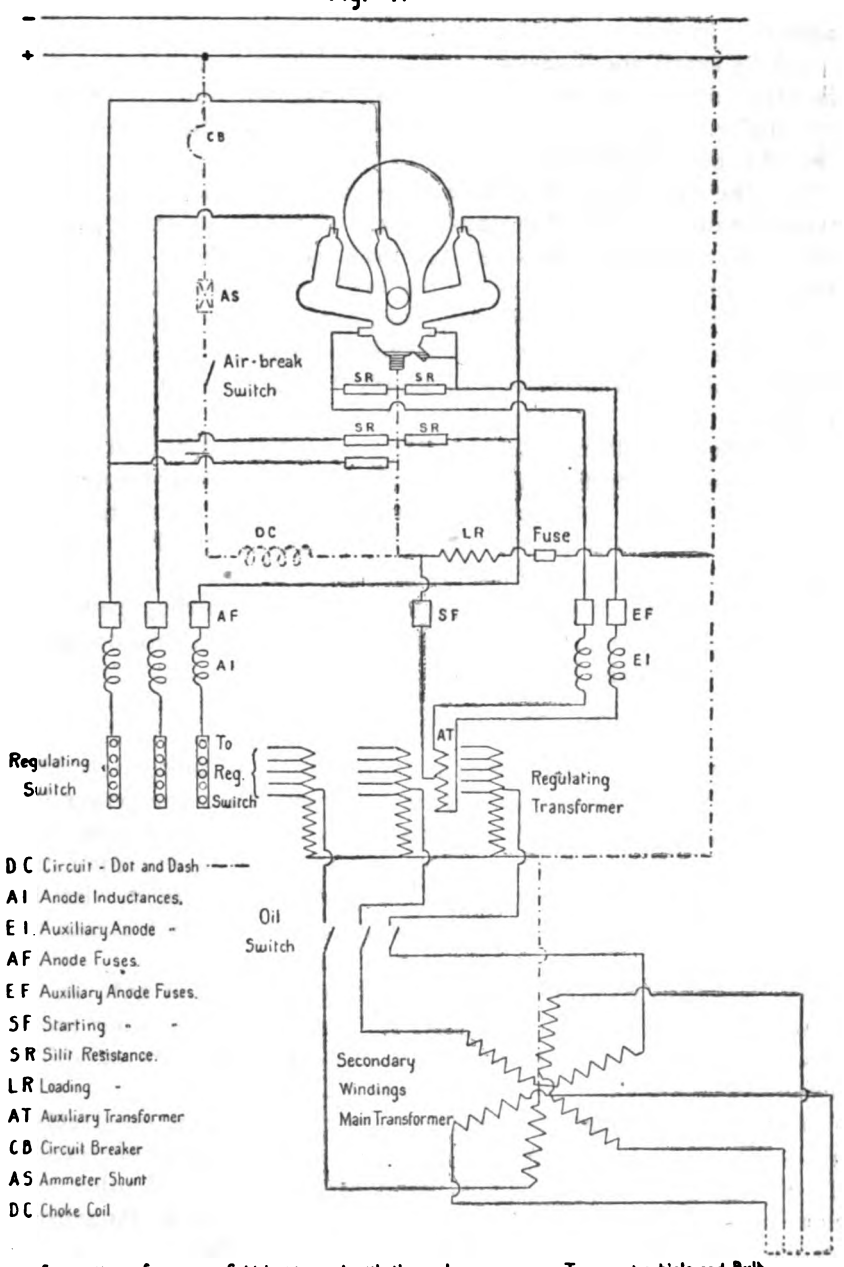
neutral points brought out separately. Each winding feeds one regulating transformer and bulb. The result is to give the equivalent of a six-phase supply, and consequently much less d.c. ripple and better power factor. Figure 4 shows the main connections for a typical example of this case. It is, of course, more expensive than (*a*).

Fig. 4.



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Several points in this diagram require further explanation.

(1) The starting and auxiliary electrodes are connected through a relay and solenoid, neither of which is shown, to an auxiliary single phase winding on one limb of the auto-transformer, so that when the a.c. switch is closed the solenoid automatically tilts the bulb and starts the arc; and the auxiliary electrodes maintain it until the load rises sufficiently to bring the main electrodes into action.

(2) In every anode circuit a "silit" resistance, made of carbon, is fitted across the arc to damp out surges arising externally or internally. Surges often occur which, without these resistances would cause a flash-over.

(3) The fan is supplied with three-phase current from separate windings on the regulating transformer. It is brought into operation by a relay (not shown) when the load rises to about 30% of the bulb rating, and cut out when the load falls below this.

(4) For traction purposes where voltage regulation is less important the regulating transformer can be dispensed with; a small transformer only being necessary to supply the fan and auxiliary electrodes.

(5) When a bulb is under load the core of the d.c. choke coil is magnetically saturated, and a considerable voltage drop occurs in it. A current of 3 amperes is required to produce saturation, and when the load falls below this the voltage absorbed in the coil becomes of course very small, and a rise of about 15% in the d.c. busbar pressure would take place were not a loading resistance (LR in Fig. 4) provided and arranged to be brought into operation by a relay when the load falls off.

CHARACTERISTICS.

Efficiency. The main loss in a rectifier is occasioned by the voltage drop across the arc. This being constant, the power loss is proportional to the load, giving a nearly constant efficiency at all loads. Also, as this voltage drop is constant, the efficiency of a rectifier will rise as its supply pressure rises. With three wire d.c. distribution, therefore, rectifiers should always be put across the outers.

For a d.c. voltage of 550 the efficiency varies from 95% at full load to 90% at $\frac{1}{4}$ load, including transformer and all other losses. For a pressure of 400, the corresponding figures are 93% and 88%, while for 110 volts 81% is a fair full load efficiency.

Overload. Momentary overloads, such as occur on traction systems, cause no damage, but the overload performance of rectifiers is poor and can in no way be compared with that of other converting apparatus; even 10% for an hour being dangerous, causing overheating and possibly damage to bulbs.

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Power Factor. With a three-phase system such as (*a*) on page 488, a value of .89 over all loads is usual. If a higher figure is required .93 — .94 can be obtained by using the six-phase arrangement.

Owing to the shape of the d.c. current wave, a rectifier has an inherent lagging power factor, quite apart from that caused by the use of reactances. When fed with six-phase alternating current this is .965, and cannot be improved by condensers. However, experiments have shown that when this current is superimposed on a lagging sinusoidal current, the resultant wave sometimes has a higher p.f. than either wave alone, and practical results may ensue from this discovery.

Bulbs. The vacuum obtained on manufacture is .003 mm. of mercury; the sealing off process is a more or less secret one. The vacuum improves with use, and if not overheated the life of a bulb should be indefinite, lives of 40,000 hours being reported from America.

In England many breakages occur in the first year after installation; in Birmingham, where a large number of rectifiers are in use, the *average* life to date is 8,000 hours. This figure can easily be improved upon; the bulbs at Birmingham are supplying an increasing load and running under exceptional conditions. Cracks usually occur where the anode wires are fused into the bulb.

The golden rule is to instal a large enough fan and to avoid overloading.

Regulation. As previously stated, the inherent regulation is about 7%. This is good enough for traction loads, but for lighting purposes a regulating transformer has to be provided.

Load sharing. It sometimes occurs that one bulb in a bank will not take its share of a light load. This failing is often due to the anode reactances of the various bulbs not having precisely the same value, but, when these have been checked and found to be correct, a cure may sometimes be effected by placing a metal band round one arm of the slow bulb and connecting it to the cathode. Presumably the action is analogous to the "grid" action in a thermionic valve.

Forming. With a steel cased rectifier the anodes have to be "formed," *i.e.*, subjected to a light load for fairly long periods, on installation and, except in the very latest types, reformed after being out of use for some time. Glass bulb rectifiers do not require this and can be switched straight on to full load.

Main Transformer. Paradoxical as it may appear, the secondary windings of a transformer to supply rectifiers have to be designed for, in the six-phase instance, 160% of the rectifier output. This is due to the fact that each phase in turn has to supply the whole d.c. output for that portion of each period during which the voltage in that phase is higher than in either of the other two. Conse-

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quently the alternating current wave form is much distorted, and the ratio of the root mean square to the average value is high.

Advantages.

(1) Their high efficiency at low loads is one of the main advantages of rectifiers. It is specially important for rapidly fluctuating loads and places where the load is growing and the load factor is low. Rotating converters under these conditions show an extremely poor efficiency.

(2) Simplicity. Starting up is done by closing one a.c. switch, and an automatic rectifier sub-station is far simpler than an automatic rotary one with starting and synchronising relays, and the rest.

(3) Low first cost and maintenance. The makers claim that rectifiers are cheaper than rotaries, but, for non-automatic stations of 500 kW. and over, it is not considered that this claim can be justified. The cost for both types of plant is at present about the same.

(4) Neatness. As can be seen from Figure 5, a rectifier sub-station presents a very neat appearance.

(5) Silence in running.

Disadvantages.

(1) Low overload capacity. As a result of this a bigger plant capacity must be installed with rectifiers than with rotaries, but this is largely balanced by the high efficiency of rectifiers at low loads.

(2) Reliability. It must be remembered that rectifiers, although in common and increasing use, are at present in the development stage, and not yet as standardized as rotary and motor converters.

(3) Telephonic interference. The peculiar shape of the d.c. wave has in some instances given serious trouble when mains have run close and parallel to trunk telephone lines. Where this has been unavoidable the trouble has after much experimenting been cured by introducing a resonant shunt (a condenser and reactance in parallel, and tuned to resonance with the troublesome harmonic) across the rectifier. It should be added that rotaries are by no means free from objectionable d.c. ripples.

Most of the usual troubles occur during the first six months of working, and it is believed that where the engineer is prepared to give the plant close attention and adjustment during this period it will afterwards prove satisfactory.

Bulbs are made in sizes up to a capacity of 200 amperes, and a voltage of 600. Small sizes can be had for any voltage.

Fig. 6 gives a view of two cubicles from the back, with their enclosing plates removed.

The cost of plant varies widely with the degree of automaticity and voltage regulation required; a three-phase arrangement is

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also considerably cheaper than a six-phase one, one regulating transformer being sufficient for two cubicles. The cost of the complete plant was in 1925 from £5 to £10 per kilowatt continuous output. Bulbs to carry 150 amperes were from £45 to £50 each.

It is of interest to note that the prices of equipment to supply the same current at 600 and at 200 volts are as four to three. Three times the power output at the lower voltage is thus obtained at the higher for an increase in capital cost of one-third. For this reason also, therefore, rectifiers are always put across the outers of three-wire systems, separate arrangements being made for balancing.

No trouble need be feared from vibration. Experiments were carried out at Woolwich, bulbs being suspended near 12-inch guns in action, but no breakages occurred.

Latest Developments.

The use of resonant shunts is mentioned elsewhere. English and German manufacturers are experimenting with (and will now quote for) plant embodying oil cooled bulbs, and delivering 500 amps. d.c. per bulb. The problem of oil cooling is different from that met with in transformer practice, as in the latter case there are no definite hot spots, such as the anodes and cathode, to interfere with convection currents.

Bulbs with six arms for six-phase supply have also been manufactured.

The writer would like to express his thanks to the Hewittic Electric Company for their courtesy in allowing him to visit their works and in supplying him with many of the figures in this article.

APPENDIX.

The action of the inductance is not very clear without analysis.

If $e = E \sin\theta$ is the E.M.F. applied to each anode circuit the current i at any instant is given by the equation

$$e = E \sin\theta - 15 = ri + L\frac{di}{dt} \quad \ldots\ldots\ldots (1)$$

15 being the voltage absorbed in the bulb.

r and L the resistance and the inductance respectively.

Now $\theta = 2\pi ft.$, and if $x = 2\pi fL$, $x\frac{di}{d\theta} = L\frac{di}{dt}$

and $$ri + x\frac{di}{d\theta} = E \sin\theta - 15$$

This is a linear differential equation of the first order, from which we find

$$i = Ae^{-\frac{r}{x}\theta} + \frac{r \sin\theta - x \cos\theta}{r^2 + x^2} E - \frac{15}{r} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

To determine the constant A

we may put $i = 0$ when $\theta = \tan^{-1}\frac{x}{r} = \alpha$

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Substituting the value so obtained for A we find

$$i = \frac{E}{\sqrt{r^2 + x^2}} \sin(\theta - \alpha) - \frac{15}{r}\left\{1 - \epsilon^{-\frac{r}{x}(\theta-\alpha)}\right\} \quad \ldots\ldots (3)$$

The curve of Figure 7 is mainly plotted from this equation, making the following assumptions:

E = 100 volts.
r = 9 ohms.
x = 4.36 apparent ohms.

from which the power factor is found to be .9 and α = .455 rads.

This curve and the equation (3) show the two effects of the inductance. The second term is the "spreading out" of the current past the zero point; the term that includes sin $(\theta - \alpha)$ shows the lag of the current on the applied pressure by the angle α.

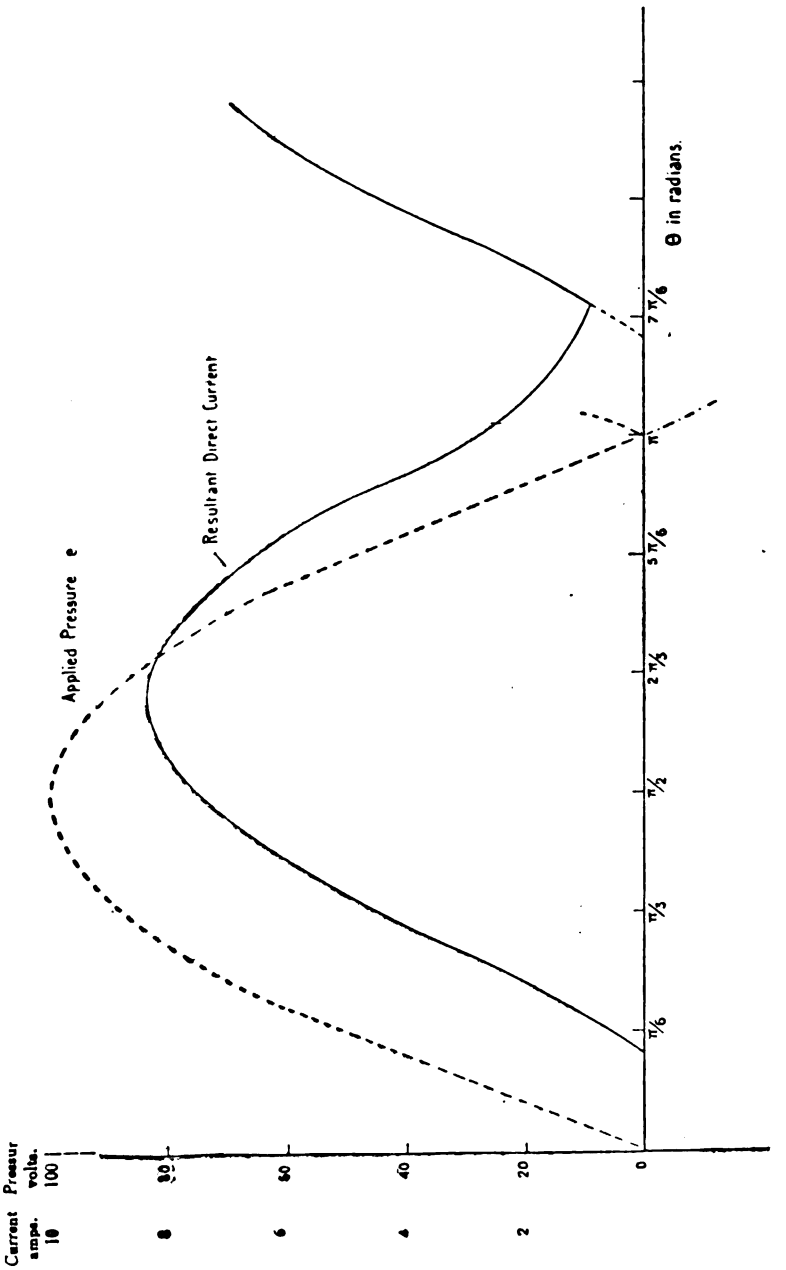

Figure 7.

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ircuit Breaker

A.C. Switch

D.C. Switch

Motor for Regulating Gear

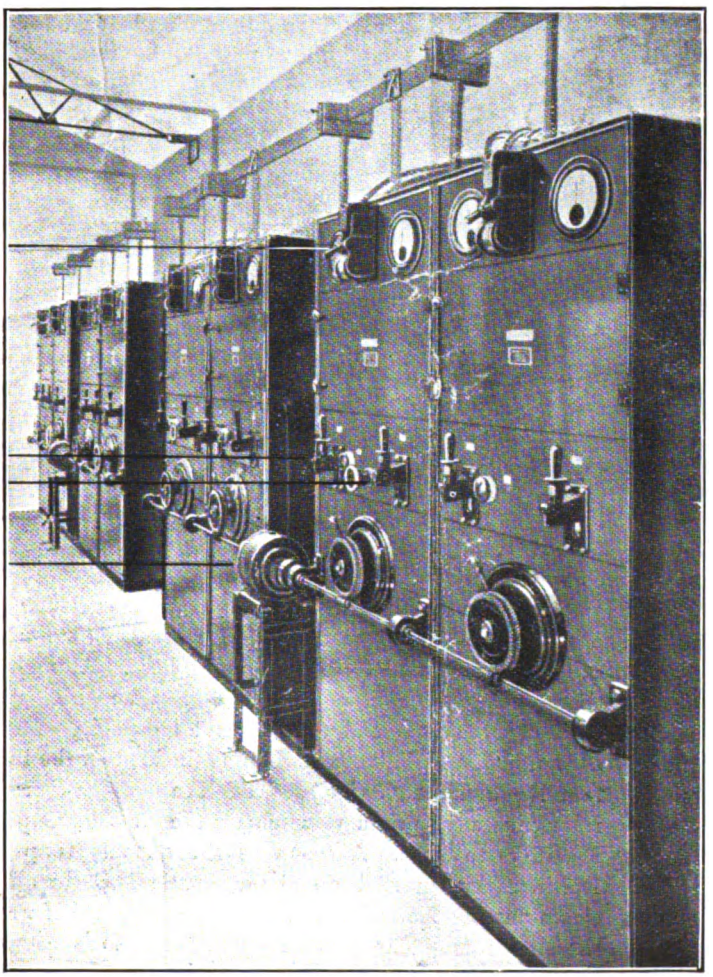

Fig. 5

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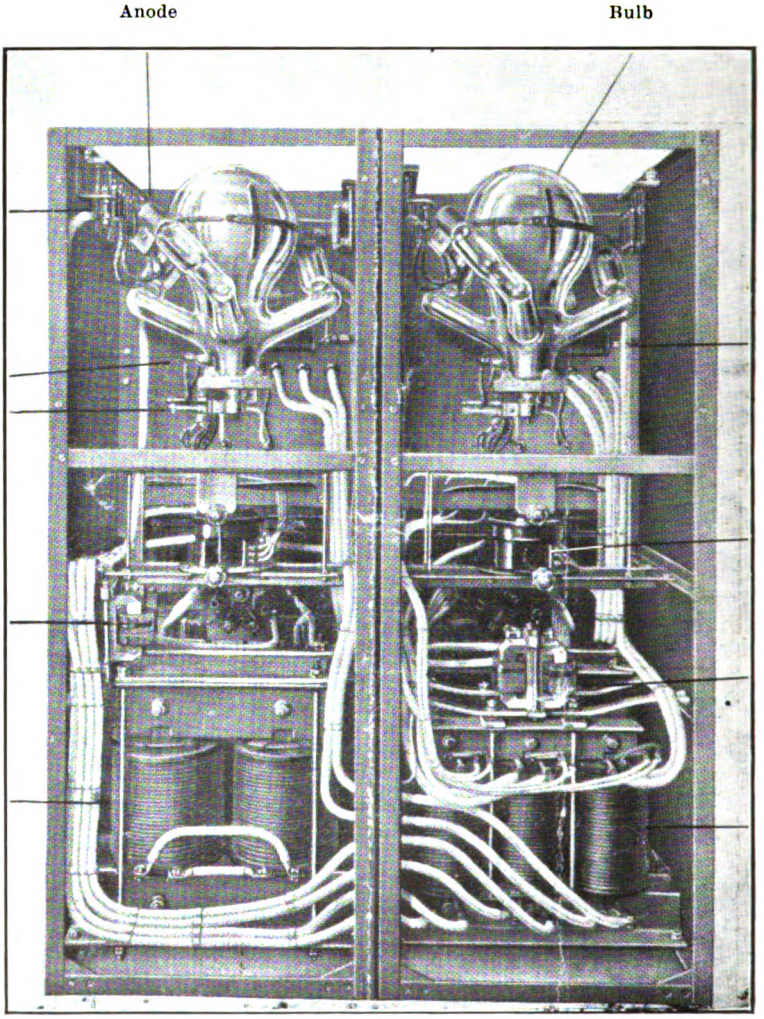

Fig. 6.

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THE BOYS' TECHNICAL SCHOOL.

By A PARENT.

The experience during the years succeeding the Great War completely demonstrated the impossibility of continuing to rely on the recruiting of tradesmen from civil life for the technical personnel of the Army and the only practical solution was the training of boys in much larger numbers than before 1914.

A Central Training School for this purpose was opened at Aldershot in 1922, but this was a temporary measure pending a decision as to its permanent location. Blandford (Dorset) was originally selected, but this was subsequently changed to Beachley, near Chepstow (Monmouth), and to this place the transfer of the School was effected, and the 25th September, 1923, is officially recognised as the Foundation day of the "Boys' Technical School," the change in name being effected at the same time as the change of station.

It was decided that 1,000 boys should be enlisted for three years boys' service as apprentices under training, and that on being posted to the ranks they should serve for eight years with the colours and four on the reserve, and be drafted either to the R.A., R.E., R. Signals, Royal Tank Corps, R.A.S.C. or R.A.O.C., as required.

By process of elimination it was decided that of the sixteen trades required in the Army the following should be taught at the School in required proportions :—

1. Blacksmiths.
2. Carpenters and Joiners.
3. Electricians.
4. Fitters.

For these, boys would be enlisted at the rate of about 330 a year, so that from the end of the third year there would be a constant supply of that number of trained tradesmen available to meet the needs of the Corps mentioned.

It must be readily admitted that the idea is very sound, as not only will it bring great benefit to the Army generally, at the time in its history when the importance of mechanicalisation is paramount, but also it is of the greatest benefit to the youth of the country at a most unfavourable period, resulting from the effects of a long period of warfare. The expense involved in this enterprise is obviously not light, and it was not projected in any spirit of philanthropy, but with the main view of attracting the best type of youth to carry out the important duties of skilled mechanics in the Army.

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To ensure this a competitive examination is held every four months at the various regimental depots and other centres throughout the country, and 110 boys are selected in order of merit for admission to the School.

The standard of the examination is equivalent to the old 2nd Class Certificate of Education, and candidates must be between the ages of 14 years and 15–4/12 years at the date of the examination.

While at the School they receive pay at the rate of 1s. per day, increasing to 1s. 2d. as they become efficient.

After being clothed and equipped the new entrants are put through a course of regimental training, drill, physical training, barrack routine, etc., the main object being the formation of a disciplined body for delivery to the workshops, there to commence the chief role of their life, to be trained as apprentice tradesmen.

The organisation of the shops, compilation of a suitable syllabus and the supervision of instruction devolves upon the Chief Instructor, assisted by Assistant Instructors and a staff of expert N.C.O. tradesmen drawn from the various Technical Corps.

Education is carried out under an Education Officer of the Army Educational Corps and embodies Mathematics, English, Chemistry, Heat and Applied Mechanics, and from "Reveillé" to "Lights Out," the boys are fully occupied in carrying out a syllabus which must be described as wholly comprehensive, containing something of everything vital to the training and welfare of a young soldier. Two afternoons a week are devoted to sport and the lads are insatiable in this respect. As they develop in size and weight they will, no doubt, provide formidable school teams and perhaps make history in Army Sport. Each week progress is noticeable, and thanks to the example of Officers and N.C.O.'s who are indefatigable in their efforts to make the boys happy, "Esprit de platoon" is soon created.

This has since been extended to company and workshop, without which, competition, the greatest incentive to progress, is lacking.

The seed was sown at Aldershot in a garden represented by those few boys who first formed "A" Company. Most of it fell on fertile ground—very little on stony patches—and, soon fertilizing, produced a pattern for those who came after to be guided by and enlarged upon. Some of the seed proved more fertile than the rest, standing out by reason of character.

Leaders among the boys themselves sprang into being, possessing personality, tact and understanding. Such boys were promoted to Boy Lance Corporals and have proved invaluable. Each commands a section of about a dozen other boys; certain privileges are accorded them, and in their barrack room their word is law. Each of these Lance Corporals is selected for his good character

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and influence, and a boy must prove his all-round worth before he is considered for promotion to this exalted rank.

No doubt, as time goes on, the idea will be enlarged upon. Indeed, even at this date we find Boy Corporals (the correct term is "Apprentice Tradesman" Corporal, as the rank of "Boy" has now been superseded) and in time to come, no doubt, promotion to A.T. Sergeant will occur and there may even be an A.T. Sergeant-Major.

Every effort is being made, and with some considerable success, to introduce the Public School System—there is no better—but this can only be realised when the boys become older and gain more experience. Not an instance has occurred of a boy N.C.O. taking advantage of his position. On the contrary they are respected and looked up to by the others, and to see them "father" the new arrivals at the School is a pleasing revelation.

The material is excellent and the scheme is progressing well, but the responsibility of the Platoon Commanders (selected Infantry N.C.O.'s) is very great. Their example can be beneficial—or detrimental.

At this stage it may be desirable to give a brief description of Beachley.

The situation is unique, a glance at the map will prove this, consisting of a peninsula separating the mouths of the two large rivers, the Severn and Wye, being thus enclosed by water on three sides. Beachley, about four miles from Chepstow, at one time a beauty spot for visitors, has been the scene of two large Government enterprises. In 1916 a National Shipyard, designed as one of the largest ship-building yards in Britain, was commenced in conjunction with another of similar type at Chepstow, and by the end of 1919 the expenditure on it had exceeded five million pounds. Early in 1920 these were sold to a company and remained idle for a considerable time.

In 1923 the Boys' Technical School took up its position there, with, we feel sure, more successful results.

It was no mean task to adapt the site to suit the requirements of the youngsters so as to afford maximum comfort, facilities for military and technical training, recreation and adequate accommodation for the large staff, both married and single, but already things are beginning to approach the ideal and Beachley Camp is becoming more complete as time goes on.

The first thing that strikes the newcomer is the cheery aspect of the barrack rooms, institutes and buildings generally. There is none of that drab colour about them, the predominating colour is bright green, with white painted ceilings, the whole well lighted with electric light, while red roofs complete the picture. The exterior walls are colour-washed in light buff.

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The Barrack Rooms, of the same pattern for the staff and the boys, are considered to be among the most up-to-date and comfortable in the kingdom. They are lined with match-boarding, sanitary annexes are connected with each, thus preventing unnecessary discomfort in inclement weather, and in the original buildings double fireplaces are substituted for that horrible invention, a stove.

Each platoon sergeant has a well-appointed quarter adjoining one of his barrack rooms, while an important innovation in each room is the boy corporal's bunk, which affords him privacy, one of the many advantages of his rank.

Much keenness and ingenuity are shewn among the boy N.C.O.'s in making their bunks attractive, and already a competition has taken place in which the judges had a most difficult task in awarding the prize for the best kept bunk.

The Supper Bar is a most attractive room capable of holding 500 at one time.

The Billiard Room forms an annexe wherein are displayed trophies and photographic groups, while the several tables are daily in use from opening to closing time. This forms the favourite rendezvous of the Padre, who unless something very pressing prevents him, devotes as much time as he can afford to assisting the boys in some way or other, and getting to know them better.

Another large room is the Reading, Writing and Games Room—with a first-class dancing floor—the scene of many successful social functions. The huge Dining Halls and the various labour-saving devices for the cookhouse are of the best. When it is understood that some 4,000 plates have to be washed daily, the necessity for the plate washing machine is immediately established.

Two large Bathhouses, fitted with shower and slipper baths and capable of dealing with 100 at a time, are working and to pass by these buildings during " business hours " reminds one of a certain part of the Zoo.

The Gymnasium has been described by a senior officer of the A.P.T.S., as the best lit and one of the best equipped in the Army. It is needless to remark that the boys enjoy every minute of the unavoidably short time allotted to physical training, and are frequent voluntary visitors to the building.

Recreation Grounds are available and sufficient and provide for cricket, hockey, rugby and association football.

A Swimming Bath is an urgent need, as although two rivers are quite handy, they are unsuitable for bathing owing to the dangerous currents and mud.

The Staff quarters are in a separate part of the Camp and are self-contained with their barrack rooms, institutes and dining hall. They are of a similar type, though on a smaller scale, than those of the boys.

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Accommodation is not sufficient at present for the families of the officers but hopes are entertained that this drawback will be soon overcome by the erection of several attractive houses on an existing delightful site. The married Warrant Officers and N.C.O.'s are, however, well catered for. Their quarters are in Pennsylvania —a model village composed of semi-detached villas, each containing three bedrooms, one sitting room, bathroom, kitchen and scullery, with gardens back and front. They are, therefore, larger than the " C " Type quarter and more artistic. The only disadvantage is their distance from the Camp—two miles away—and travelling to and from work constitutes a certain amount of inconvenience, especially in bad weather. Furthermore, there is the serious danger of the married families getting out of touch with the social life of the school, which is vital to the maintenance of good feeling and family spirit. However, by means of a really excellent Cinema Hall at Sedbury, opposite Pennsylvania, gatherings of the pupils and their instructors have taken place on several occasions, when the " off duty " spirit has prevailed and thus opened the way of getting to know each other.

Anything more unlike the typical Officers' Mess building than the accommodation for the officers cannot be imagined. Instead, Beachley Camp is fortunate in possessing a charming old mansion, standing in beautiful grounds, with a view across the Severn, which is really delightful. The rooms are large and artistically decorated, while two excellent tennis courts are available. Legend has it that a ghost completes the inventory, in the form of a butler carrying drinks, but although one or two sympathetic and non-teetotal spirits have attempted liaison after hours, no success has so far crowned their efforts.

The Workshops consist of magnificent structures and are capable of accommodating 900 boys at one time. Every modern device has been introduced and appearances tend to the belief that they are the best of their kind in the Service.

A large number of excellently equipped classrooms for education, each seating about 40 boys, as well as two Laboratories, Mechanical and Chemical, are also in use.

The School, under the Commandant, is organised in three branches, (*a*) Headquarters; (*b*) Administrative; (*c*) Instructional; each being directly responsible for its particular business. At the same time the fact that each is an integral part of the School is not lost sight of. It would never do to work in watertight compartments, and by interchange of ideas, mutual co-operation in arranging social functions and liaison between Barrack Room and Workshop, this feeling is inculcated.

The Headquarters comprise the Adjutant and Quartermaster and the Instructors and Dutymen.

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The Administrative branch comprises four companies, each of about 220 boys, each divided into four platoons. The Company Staff are:—One Captain, C.S.M., C.Q.M.S., four Lance-Sergeants and a Storeman.

The platoon sergeant has an important command in controlling some fifty boys and is assisted by the four section commanders (boy N.C.O.'s). No finer opportunity exists for a young N.C.O. to develop, with the material at his disposal, those qualities which make leaders.

The instructional branch is supervised by the Chief Instructor, assisted by three assistant instructors, whilst each workshop is under the direct control of a Warrant Officer Instructor assisted by certain N.C.O.'s, who remain in charge of the same boys as long as is practicable.

The Education Officer is responsible with his staff for the general education and for a great portion of the technical instruction which forms a vital part of trade training.

The messing at the School is really excellent, even supper being served to the boys on four nights weekly.

Education, a high moral standard, sportsmanship in its true sense, esprit de corps, self-confidence, respect for superiors, and discipline, are a few of the keywords of the B.T.S., and no parent, however fastidious, need have the slightest qualms about the company a boy mixes with at the School.

One has but to speak to the boys to realise that in the majority of cases they have been well brought up and come from good homes. Competition to obtain admittance is so keen that the places of any delinquents could, if necessary, be filled a dozen times over.

A School Concert Party is now in being and has given several successful shows—a revue "Laugh Now" was accorded a very warm reception at the Town Hall, Chepstow, a few months ago.

The School journal, "*The Robot*," is published periodically, and I am indebted to its Editor for much of the information contained in this article.

"MASKEE."

DISSECTION OF HEPTAGON.

With reference to the Dissection of Heptagon published on page 368 of the June, 1926, *R.E. Journal*, a correspondent writes:—

"I read the letter to mean that the heptagon was accurately dissected into a square, whereas it is only an approximation. If the dissected parts are to fit accurately together, the resulting figure is a rectangle whose sides are (left to right) 1.93586 and (up and down) 1.87715 times the side of the heptagon respectively."

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Major Sir Robert Hanbury Brown, K.C.M.G., late R.E.

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MEMOIRS.

MAJOR SIR ROBERT HANBURY BROWN, K.C.M.G.

HANBURY BROWN, the son of Dr. Robert Brown, F.R.C.S., was born on the 13th of January, 1849. He was educated at Marlborough College and at the Royal Military Academy at Woolwich. He joined the army as a second Lieutenant of Royal Engineers on the 8th of January, 1870, and was at the School of Military Engineering, Chatham, until July, 1872. He went to India in November of that year. In 1878 he was married to Marian, the daughter of the Revd. Edwin Meyrick, who was at that time Rector of Allington, Wiltshire. He had two sons and one daughter. His younger son, Bt. Major Austen Hanbury Brown, D.S.O., M.C., Royal Engineers, served with the 8th Division in the 2nd Field Co. R.E. and was killed at Rosières, Somme, in March, 1918.

On his arrival in India, Hanbury Brown was posted, in the first instance, to the Bengal Sappers and Miners at Roorkee. In March, 1873, he was appointed an Assistant Engineer in the Public Works Department of Bengal and served in the Irrigation Branch of that Department until 1884. During his service in India he was called up for military duty in the Afghan campaign of 1878-80, and was mentioned twice in despatches. In 1884, Egypt badly needed Irrigation Engineers to control and develop the great Irrigation works of the Nile, and Hanbury Brown was deputed, with others, for the work; he did much for Egypt and lived to see the land he had helped to irrigate increase vastly in fertility and value. His service in Egypt extended over nearly twenty years. He was awarded the Egyptian Orders of the Osmanieh, 2nd Class, and the 1st class Medjidieh. In 1902, he was made a Knight Commander of St. Michael and St. George in recognition of his services in Egypt. He was Inspector General of Irrigation of Lower Egypt for some years before he retired from the Egyptian Service in 1903. He was elected a Member of the Institution of Civil Engineers in 1904.

The writer recalls a little incident in the life of Sir Hanbury Brown which is typical of the man. When he, with two or three others, was walking one day along the crest of an embankment in India the bank suddenly collapsed under his feet and he, and a coolie who was walking close by him, fell together into a cavity in the heart of the embankment. The position of the two was somewhat critical and decidedly unpleasant. He refused to be helped out of the pit until the coolie had been first hauled up.

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Nearly the whole of the professional life of Hanbury Brown was spent in the design, construction and administration of Irrigation works. As a young Assistant Engineer he helped in the construction of the Patna Canal, which is one of the main branches of the system of Canals drawn from the Sone river, which irrigate some 600,000 acres of rice and other lands in the Behar district of India.

In Egypt, one of the most useful works constructed by him was the Zifta Barrage on the Damietta branch of the Nile. This work regulated the distribution of the water, and the cultivators realised a rich harvest in the improvement in the area and out-turn of their crops. But the work which firmly established his reputation as an Engineer, and which he himself probably regarded as the most interesting and satisfactory, was the work he did in ensuring the stability of the great Delta Barrage across the Nile below Cairo which was constructed by Mougel Bey before the British occupation of Egypt. This stability was secured, first, by a system of grouting the original Barrage itself, and then by the construction of two subsidiary weirs below that Barrage. In 1902, Major Hanbury Brown published a book, "The Delta Barrage of Lower Egypt," which describes the work which was carried out. The two subsidiary weirs were built by a novel system which was mainly, if not entirely, his own. He described this system in a paper, read before the Institution of Civil Engineers in March, 1904, entitled "The use of cement grout at the Delta Barrage in Egypt." For this paper he was granted the Telford Medal. In the discussion on the paper, Sir Benjamin Baker said, "He was convinced that when the paper by Sir Hanbury Brown was carefully studied, and the novelty involved in the details was seen, the work would be valued very highly. He believed that nowhere throughout the world, up to the present, had the capabilities of cement been demonstrated to the extent which had been shown in an unostentatious way by Sir Hanbury Brown." Sir Benjamin further remarked that the author of the paper had overcome certain difficulties which had arisen, "with the result that he had carried the two weirs across the two branches of the Nile very rapidly, and had done what had never been done before, namely, made locks on the grouting principle without any Dams or pumping."

After his retirement from the Egyptian service, Hanbury Brown was called upon, on several occasions, to give a professional opinion on irrigation matters. In this he worked in partnership with the writer of this memorandum. In Dongola, in Spain, in South America and in the Sudan his advice was sought and given. He was ready with his pen and contributed not a few articles to the Engineering Press. His article in the "Engineer" in November, 1912, on "Land values in Egypt" dealt with the benefits which the Assuan Dam in Upper Egypt had conferred both on Government and the people. He showed by statistical statements that the value

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of the land, which came under the influence of the great reservoir formed by the Dam, had increased in a period of only three years from about £192,000,000 to about £488,000,000, and, at the same time, the increased land taxes collected by the Government were equivalent to five per cent. on the Capital outlay. So that not only had the Government received full value for their investment, but the people of the country had vastly increased their wealth.

Sir Hanbury Brown was the author of several books. Among those on engineering subjects, the one entitled "Irrigation: its Principles and Practice" passed through three editions, and is one of the standard books on the subject. He wrote also on other subjects than professional ones: his "Land of Goshen and the Exodus" is a book containing an interesting study of a portion of the history of the Children of Israel, and "The Fayum and Lake Moeris" is another of his books which is fascinating in its description of that interesting depression in the desert.

Sir Hanbury Brown was always a photographer of no mean ability, as many exhibitions in the village of Crawley Down, where he lived, could testify. In his later years he took up wireless telegraphy with his usual enthusiasm. He taught himself the Morse code and amused himself, in his leisure moments, in writing down numerous messages received from all sorts of people, many of them quite uninteresting in themselves.

During the Great War Sir Hanbury was in command of the 7th Battalion (East Grinstead) V.T.C., and was subsequently second in command 3rd Vol. Bn. R. Sussex Regiment. He was always an active member of the little community of Crawley Down and Copthorne in Sussex. The Boy Scouts, the British Legion, and the Parochial Council, all felt the value of his kindly help and co-operation, while the few who now remain of those with whom he worked in India and Egypt remember how he always inspired esteem and respect in all who were associated with him.

R.B.B.

COLONEL CHARLES FREDERICK COBBE BERESFORD.

Colonel C. F. C. Beresford, whose last appointment was that of Colonel on the Staff, Chief Engineer in Ireland, was born in 1844, being the elder son of the late Rev. Charles Claudius Beresford, and great grandson of the Rt. Honorable John Beresford, *M.P.*, brother of the 1st Marquess of Waterford.

He joined the Corps as a Lieutenant in December, 1865. Of those early days, General Sir Bindon Blood writes: "I first met Beresford when I went to Chatham from Aldershot with "A" Troop in November, 1866. He was then a tall, rather slight, but very strong

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lad, very good looking, and always one of the best and most charming fellows that ever stepped. He was very fond of sailing and rowing, and he was very good at both, a first-rate hand in a boat, and a good waterman.

"We had many pleasant trips together in the R.E. Yacht Club boats, and we were in the Corps four-oar together in 1867. I remember also having a very hard tussle with 'the Long-un' in one of the heats for our Corps Sculling Race in 1867, when I won 'all out' on the post."

After speaking of later meetings, especially of a walk together in 1878, Sir Bindon Blood says: "I should put him down as a specimen of an Anglo-Irishman of the best sort, a man you could trust and depend upon anywhere and everywhere.

"His abilities were of a high order, I know, and he did well with them in the Corps."

Serving for 3 years in Ireland, after leaving Chatham, he went on for a tour of foreign service to Canada, and then to Bermuda, where he sailed his 'Mudian' with success in many races. He was always a first rate horseman, and ran the drag hounds. It is recorded by one of his oldest friends, Colonel C. Chenevix Trench, R.A., that after an attack of enteric fever, he was taken to Government House to be well looked after, and when asked by Lady Lefroy, the wife of the Governor, what he would prefer for breakfast, laughingly answered "Please give me a red herring every time."

On his return home, after a spell of leave, and some hunting in Ireland, he was posted to the G.P.O. Telegraphs in 1873, before joining, for 4 years, "C" (Telegraph) Troop at Aldershot, under Major Durnford. He was always an ardent advocate of the alliance between military and civil telegraphs, but those were days when military telegraphs were in their infancy, and the equipment available was farcical, signalling being also the business of the troop, and the more important of the services.

In 1877, he joined the Institution of Electrical Engineers as a Member, being elected to the Council of that Institution ten years later.

Of those happy days at Aldershot, when most of the training of the army was carried out in the Long Valley, and on the Fox Hills, and the principal thing insisted on by H.R.H. The Duke of Cambridge was that officers who could should be allowed to hunt four days a week, very little beyond the joy of life can be recorded.

General Sir Richard Harrison remembers Beresford then as a tall dark man, good at his work, and at anything he undertook, especially tent pegging. His friends of those days will remember the good horse "Cockchafer," who bore him to victory in the Army tent pegging at Lilley Bridge in '76, and again at Aldershot, and later on in London, when he won the lemon cutting also. Those

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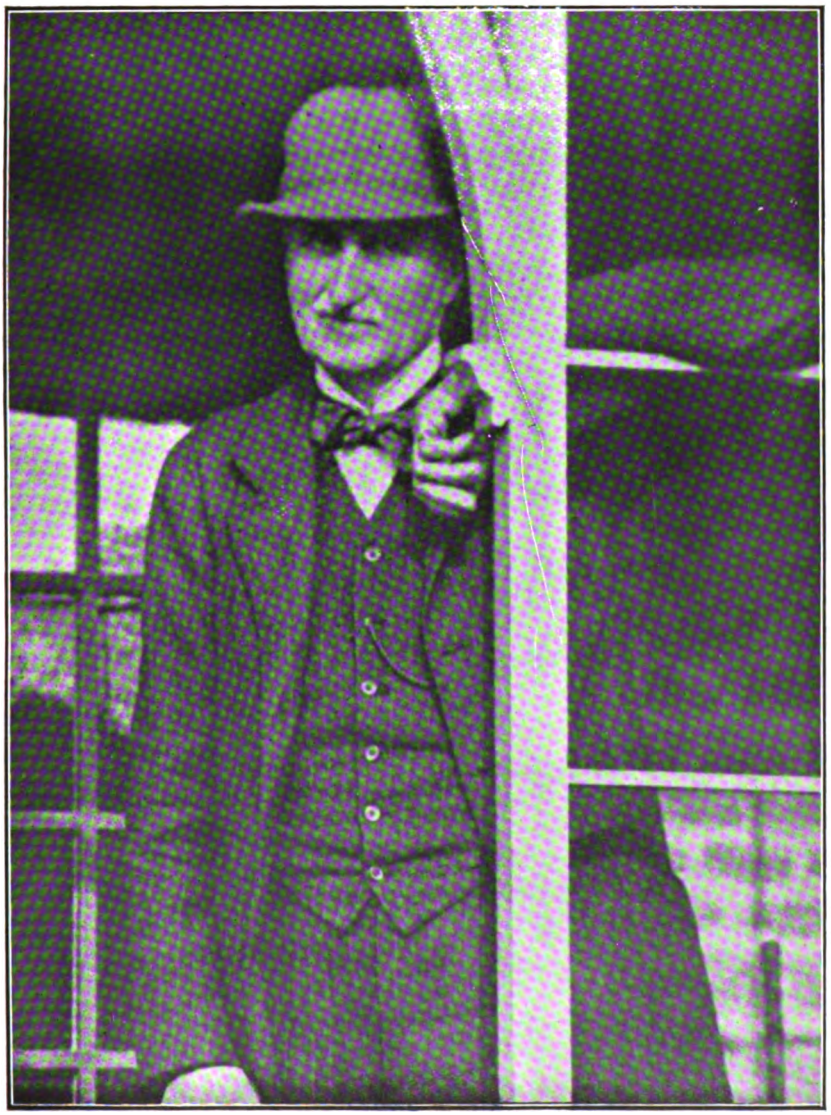

Colonel Charles Frederick Cobbe Beresford.

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were the days also of his constant friend "Smut," the bull terrier, who never let go when he accepted battle.

It was in '75 or '76 that Beresford, Bagnold and Mackean built what Colonel A. H. Bagnold now speaks of as "a monument of his talent for initiating good useful movements," the R.E. Theatre at Aldershot. "I still have," says Colonel Bagnold, "a photo of the skeleton of the building, C.F.C. standing on the ridge, self sitting on it, and Kenneth Mackean perched on the eaves. It might well have been named 'the Beresford Theatre.' Todd, Beresford and MacGregor were the three senior subalterns whose friendship and influence I have ever been grateful for."

Colonel Bagnold also records a certain fancy dress ball at Guildford, at which Beresford appeared as a White Knight, the coming out ball of his future wife.

The following year he was married to Edith Gertrude, daughter of Salisbury Baxendale, Esq., of Bonningtons, Ware. To the never-failing happiness of that union, and to the added joy to his many friends, we may only thus briefly refer.

Colonel Stanier Waller, another old friend of that time, says: "My principal recollection of the 'Long 'Un' is his extreme cheeriness under all circumstances. I don't think I ever saw him seriously put out."

Though his fun, cleverness of wit, and cheeriness come first in all memories of Beresford, those who knew him well, can tell of his strong purposeful character, and capacity for hard work. His fine riding and reckless gallantry, his single-minded pureness of heart, and intensity of purpose made him a beau ideal soldier, but chance prevented him from the opportunity of fulfilment of the brightest of early promise.

Beresford, in 1878, was promoted Captain; in 1879 he passed high for the Staff College, completing his course at the end of 1880. To his disappointment, he had not been, therefore, able to go to the Zulu campaign. It was there that an old friend, McDowel, of the R.E. Troops, was killed at Isandhlwana in 1879, and there also "C" Troop was first extended, learning the necessity for a far larger equipment, using heliographs successfully, and for the first time making use of the Bell telephone.

His first active service was in the disastrous campaign in the Transvaal of 1881, where he rendered excellent service, the campaign in which his old friend John MacGregor, formerly Adjutant of the R.E. Troops, and then Military Secretary to Sir G. Pomeroy Colley, was shot through the head.

Of the disaster of Majuba, the death of Colley, and the winding up of the campaign politically without honour, the story is well-known.

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On his return from Africa in 1881, he was posted to the Intelligence Branch of the War Office, serving there till September, 1883. He, therefore, missed employment once more in South Africa, with that wonderful little force under Sir Charles Warren, known as the Bechuanaland Field Force, which took many of his old friends, under Major R. H. Jelf, from Aldershot, clad in corduroy and wideawake hats, with beards on the cheeks and chins of those who could grow them. Of how the Boers, missing the familiar red coats, could make nothing of them, and, puzzled by the skilful manœuvres of Sir Charles Warren, sued for peace, is not part of this memoir.

Beresford's chance came again in 1885, when he was sent to the Soudan as Director of Telegraphs, but fate decided that the campaign should collapse after 3 months of his service there, and though he received the medal and clasp, and bronze star, his time with the Force was too short for the gaining of honours, though again the record of his work was excellent.

That year he was promoted Major, and following his bent, he was given command of the 2nd Division of the Telegraph Battalion, employed on the Postal Telegraphs, in which he remained for four years, with his headquarters in Leicester Square.

Of this time, Sir Ralph Anstruther, one of his subalterns, writes: "Well do I remember his cheery optimism under a very severe snow breakdown, we drove together in a waggonette with various changes of horses all the way from Polegate to Bromley, deep snow, brilliant sunshine, and devastation all along the Newhaven main line. He was a versatile companion at all times, and an inspiring C.O., for his subalterns. He was always for pushing on both officers and men to the limits of their capacity. I recollect his reproaches when I deprecated the removal of my right-hand man at New Cross to some more exalted sphere. 'My dear fellow, you must not talk like that; always let your best men go to something better, and their successors will be tumbling over each other to get advancement too.' He was so clever and quick-witted, and the humorous element in all situations appealed to him strongly. Altogether a man who could not fail to be admired and liked by all who served with him."

In 1889, he was selected to command the 1st Division of the Telegraph Battalion, and it was his good fortune to see the progress so far made in Military Telegraphs, which he had so ardently furthered throughout his service.

Even so, the standard was still far below that to which the T.B. attained later on. What was attained was a real foundation on which the war edifice of Military Telegraphs, culminating in the splendid Royal Corps of Signals, was built.

Major General Sir H. Bruce-Williams bears witness that "Beres-

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ford was a very kind C.O., and always took the kindly view of officers or men. He took it for granted that they were doing their best, and under him the 1st T.B. was a happy family.

" Colonel Beresford, being an Irishman, was a good horseman, and encouraged the mounted portion of the unit."

General Bruce-Williams speaks of how the standard of horsemastership, and the technical training, in 1890 were still far below that of the Great War; the army being in a state of transition, only beginning to learn and to teach itself, and life being not so strenuous as it gradually became after South Africa, and as it is now. He adds, " But if it had not been for him I could not have boasted of having a ' chit ' to the effect that the horsemastership of the 37th Division in 1917-18 was the best in the 3rd Army during the war. He delegated authority freely to all subordinates alike. ' Out of School,' of course, he was a charming man. I have never seen him angry or ill-tempered in or out of school."

Perhaps one of the most charming testimonies of his old subalterns is that of Lt.-General Sir John Fowler, who writes : " When I joined the old ' T.B.' as a subaltern in 1888, Charley Beresford was in command of it. All we subalterns loved him. Very keen and practical in his schemes for our training, he always contrived to make it really practical. He constantly sent off small detachments ' on their own ' to make good as best they might, and it was this training which established traditions and habits which had good results in the South African and Great Wars.

" He took the greatest interest in the welfare of the unit, and saw to it that Officers and men shared every form of active sport, especially if a horse came into it. His subalterns of those days did well in their careers, and I am sure owed something to Charley Beresford. Bruce-Williams, Godfrey-Faussett and Boys were some of them. He always took the greatest interest in how those who had served under him were getting on.

" A good judge and keen lover of a horse, he was unable to ride much on account of rheumatism, but however much he was crippled by this, he was always out to see what was going on, cheery and light-hearted, with some little joke on the success or failure of officers and men.

" Meeting in after life, he was always full of anecdotes of the old ' T.B.' days, and many will deplore the loss of Charley Beresford as that of a very real old friend."

In the same strain Sir H. Bruce-Williams, says : " It was always a pleasure to meet Colonel Beresford long after one left the 1st T.B. He always met one in a cheery way. He had a way with him, like so many Irishmen, and both I and my wife have the happiest recollections of the kindness of Colonel and Mrs. Beresford to us."

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Sir Bindon Blood says: "I cannot put a date to the last time I saw him, but it must have been at a Corps dinner. I remember he was as good-looking and as pleasant-mannered as ever."

In 1892 Beresford was promoted Lieut.-Colonel, and posted to Ceylon, where he served three years. During his time in the island, he earned the love and trust of the natives by his advocacy of their claims when he thought they deserved it. He used to tell with laughter how on one occasion he was led, garlanded, in a great procession. He then received his Brevet-Colonelcy and was transferred to Plymouth as C.R.E.

In 1898 he was promoted substantive Colonel, and received his last appointment of Colonel on the Staff, Chief Engineer in Ireland.

In 1902, he was placed on retired pay, and after a few years in London went to live at Camberley, so as to be near his old haunts at Aldershot. There he designed and built himself a house looking out on the Camberley Heath Golf Course, laying out a charming garden round it. The following tribute from the builder who worked under his direction is worthy of record:—

"Kindly accept on behalf of myself and sons our respectful sympathy in the great loss you have sustained. It was always a pleasure to do anything for Colonel Beresford, and his kindly, courteous and genial disposition will be missed by all who knew him. He was a gentleman in every sense of the word."

There is a fine studio in the house, where he passed many hours. Friends who visited him there found always the same cheery, bright and witty personality, hard at work painting, or working in his garden. To those who knew him well, in the early days and in the evening of his life, he was always an inspiration and a joy.

The Great War found him as keen as ever to serve his country, but his age (then nigh on 70) denied him more active service than he could find in 1915 as Colonel of the Frimley Volunteers. Into this work he threw himself with his whole heart, and never spared himself in night marches, nor in all the work involved in the disposition of his men in Defence. One of his officers writes:—"I am writing on behalf of many old members of the Frimley Volunteers to say how much we sympathise with you in the loss of our Colonel. We all loved him.

"Personally I shall look upon the times I spent under him as among the most privileged and happy days of my life."

Beresford served with his Volunteers till February, 1918, though from May, 1917, onwards his activities were gradually less.

During his active life he was a constant contributor to the *R.E. Journal*, and published nine or ten articles on the use of Telegraphs and Telephones in the field, as well as on the collection and transmission of intelligence.

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When a new cover was required for "The Sapper" and a competition was opened, he sent in a very clever drawing, which was placed third. The detail, giving all the wars in which the Corps had been engaged, together with its varied uniforms, was too great to allow of its being accepted.

Devoted with a great affection to the land of his birth, his belief in the future of Ireland, even in the darkest days, never wavered.

In retirement, amongst his many interests, for 19 years he was a member of, and a very regular attendant at the meetings of the Grand Committee of the Benevolent Society of St. Patrick. The Secretary writes:—"His never-failing kindness and help will always be one of my happiest recollections."

At their meeting on the 5th March, 1926, Viscount Massareene and Ferrard in the chair, the following minute was recorded:—

"It was unanimously resolved that the Grand Committee of the Benevolent Society of St. Patrick desire to convey their heartfelt sympathy to Mrs. Beresford and her family in the bereavement they have sustained, and to express their appreciation of the long and valuable services rendered by Colonel C. F. C. Beresford to the Society."

It is sad to record that a crushing sorrow fell on the happy home at Camberley and on the mess at Aldershot in 1910.

Captain Charles Claudius de la Poer Beresford, the elder son, one of the most promising young officers in the Corps, at that time commanding the 1st Field Troop, gallantly lost his life in trying to stop a runaway horse. Undoubtedly he saved the life of the rider, a batman, as the horse was heading for his own stable door, when he thrust the horse he was riding across its path.

Colonel Beresford died on the 13th December, 1925, at the age of 81, and memorials to father and son will be side by side in St. George's Church, in the Stanhope Lines at Aldershot.

Had opportunity of greater service come his way, there is little doubt in the minds of his friends that Colonel Beresford would have risen to the occasion.

Officers and men would have followed him anywhere, and his vigorous personality, his clever brain and rapidity in making decisions, would have made him a leader of the highest order.

He had no thought of self, and was never known to complain of the rebuffs of fortune, nor to lose his bright outlook, or keenness of purpose. To put his whole soul into what he had to do, and to expect those under him to play the game, and to trust them to do it, was the secret of his entire service.

That there is now no Beresford in the Royal Engineers to carry on the tradition is a matter of lasting regret.

F.G.B.

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COLONEL C. A. R. BROWNE.

COLONEL Clement Alfred Righy Browne, who died at Ealing on the 28th December, 1924, was born in 1860, the son of General Clements Metcalfe Browne, R.E., and received his first commission in the Corps in April 1879. After completing his course at Chatham he was employed at Chatham and Aldershot until 1883, when he went to India, and was for some time employed on the construction of the road over the Bolan Pass. He was a keen cricketer and association football player, but owing to an injury to his knee he joined the Accounts Branch of the P.W.D. in 1885 and worked in the offices of the N.W. Railway in Bombay until he came home for the India class at Chatham in 1891. On his return to India he served on the Assam-Bengal Railway and afterwards in the office of the Accountant-General, P.W.D., in Baluchistan. In 1901 he was lent to the Military Department to manage the railways in China during the Boxer troubles. In March 1901, the Germans had handed over the administration of the Peking-Tientsin-T'anku-Shan-hai-Kuan railway to the British, and after Colonel (now Major-General) Sir J. R. L. Macdonald had acted as Director of Railways for a short time, Browne took over the work and managed the railways, with the co-operation of German and Japanese Deputies, until they were handed over to the Chinese late in 1902. So successful was his administration that the revenue of the line not only paid working expenses, but contributed $500,000 towards repairing the Boxer damage, expended $1.200,000 on new works and paid the bondholders interest amounting to £115,000. He was twice mentioned in despatches and in 1903 received the brevet of Lieut.-Colonel. He afterwards held several important appointments in the Indian Railways, and retired in 1915, after holding for over two years the post of Manager of the Eastern Bengal Railway. On his return home he was given the command of a Labour Battalion and served in France for six months in 1915. He was afterwards placed in charge of the Munitions Factory at Leeds until the end of the War and retired in January, 1920.

BOOKS.

THE STUDY OF WAR.

An inaugural Lecture delivered before the University of Oxford on 23rd February, 1926. *By* MAJOR-GENERAL SIR ERNEST SWINTON, K.B.E., C.B., D.S.O., Chichele Professor of Military History in the University of Oxford. (The Clarendon Press, Oxford.) Price 2s. 6d.

OXFORD Unive sity has been fortunate in its Professors of Military History since the foundation of the Chair. The first holder was Mr. Spenser Wilkinson, the eminent publicist and writer on military questions.

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The second was Professor C. W. C. Oman, now Sir Charles Oman, M.P., whose "History of the Peninsular War" is a standard work. The third we all know as the author of "The Green Curve" and other books, and one of the official military correspondents who, under the name of "Eye-Witness," described the early fighting in France and Flanders in the Great War.

In his inaugural address Major-General Sir Ernest Swinton acknowledges the honour done to the Army and to the Corps of Royal Engineers by his appointment to the professorship. In him Oxford obtains a lecturer who has not only gained a reputation by his writings on military affairs, but has the advantage, denied to his predecessors, of having had personal experience in the field.

Shortly after the conclusion of the campaign in South Africa, where he had gained much experience as Adjutant of the Railway Pioneer Battalion, under the command of another distinguished Sapper, Major-General Sir John Capper, Swinton launched into a literary career as a side-show to his military work. One night, returning as "daily-breaders" from the War Office to our homes in the country, the future Professor discussed with the writer his experiences during the South African War, and broached the question of publishing his ideas on the subject of the tactical defence of localities He outlined his plan for the book, and before parting asked whether it would be worth publishing. The reply was—"Certainly, but don't let it be known that it is written by a Sapper." A few months later there appeared a modest pamphlet entitled, "Duffers Drift," purporting to be written by one "B.F.," whose portrait appeared on the cover, and depicted a khaki-clad subaltern fully equipped for war, and covered like a Christmas tree with all the impedimenta, from revolver, holster and belt, to water-bottle and field glasses, with which the British officer is wont to adorn himself for his first campaign. In it the writer gave a progressive course of lessons, in the guise of dreams, of "How not to do it," taking for his subject the defence of an important drift on an African river. In the final dream "B.F." managed "to do it" and scored, like the pamphlet, a remarkable success.

Published by Clowes, the pamphlet had a large circulation—slow at first, but steadily increasing. Two or three years afterwards a distinguished officer of the Brigade of Guards let out that he had presented a copy to every N.C.O. under his command. Unfortunately, the American copyright had not been reserved, or the royalties would have been larger. It was republished in the United States, where interest in the study of war was awakening, in the Army at all events as in Great Britian.

But to return to the inaugural lecture. In these days one is constantly faced by the problem of how to combat the arguments of enthusiasts who preach the doctrine that there can be no more wars, and that consequently an Army is unnecessary. It is useless to remind them of the Holy Alliance, the Universal Peace Society, or the Hague Conference, or to plead the cause of the poor professional soldier whose bread and butter are being taken from him. But one can read General Swinton's address and use his arguments, and if the pacificists can be persuaded

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to read it for themselves, it is possible that they will not sleep quite so soundly in their beds. He provides us with a reasoned reply, which will even cheer the budding soldier who thinks he has chosen the wrong profession.

General Swinton told his audience that as regards the general attitude of the nation towards the study of military history, it was reasonable to hope that his task, by reason of the lapse of time and the course of events, would be easier than that which confronted Professor Spenser Wilkinson in 1909. But he finds that, although a great change has taken place in the nature of the opinions held then and now, there is not so much difference in the attitude which is the outcome of those opinions.

Professor Spenser Wilkinson held that the people of this country had been gradually aroused during a period of 50 years to a recognition of the fact that war is, unfortunately, a part of the life of the world, the latest step in the process of their enlightenment having been the crisis of the South African struggle, which had finally brought home to the nation the reality of a phenomenon too long ignored.

General Swinton disagrees with this last conclusion. Our insular position had prevented us seeing war at our doors. After nearly 50 years without any serious conflict to shake our complacency we were faced by what was sometimes called the *Great* Boer War. Though that war had jarred us into acquaintanceship with unpleasant realities, they had been limited, and were no measure of what might be.

In spite of its revelations, the influence of that conflict, save in the Army itself, was neither deep nor lasting. The current of our national life was not seriously disturbed. No lasting impetus was given to the study of war outside the Army.

General Swinton quotes Colonel Henderson, who wrote not long after the South African War was over :—

"History, as taught at the present day, includes an immense variety "of subjects, but there is one subject which is sedulously shunned, "and that subject is the defence of Empires. Hardly any well-known "political writer, except Spenser Wilkinson, appears to have the least "inkling that such knowledge should be part of the intellectual equip- "ment of every educated man, and no great teaching body has yet "endeavoured to supply the deficiency."

At an international historical congress held in London in 1913, Professor Oman ascribed the systematic depreciation of the study of military history "to the tendency to regard history as being purely evolutionary "and not cataclysmic—war being in the latter category—and to ignore "the influence exercised on events by individuals and personalities"—which was truly a far-seeing remark in the light of recent events. His conclusion was that the general knowledge of military history is as important as that of social, economic and political history.

The fact was that there existed, in 1913, an unjustified complacency born of a lack of knowledge, and an unwillingness to face facts or to read the signs of the times.

Since the Great War we can no longer plead ignorance as an excuse for living in a fool's paradise.

To quote again—"To urge the importance of military matters,

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"therefore, at the present time, even upon those not directly concerned "in the preparation for or conduct of war, should be far simpler than "it was.

"But there is still a lack of enthusiasm, in part attributable, strangely "enough, to overmuch knowledge—of a kind.

* * * *

"The desire to wipe out the past has crystallized into a revulsion "against war and a deep disinclination to think of it.

* * * *

"An indifference to military matters has to some extent replaced "the ignorance of former days. There is a theory that we are not "for a specific term of years likely to be engaged in a serious struggle. "Moreover, there is no obvious menace such as existed before 1914.

* * * *

"Finally, there is a school of thought that holds that by the gradual "conversion of all to the desire for peace and goodwill war can be "avoided, the process being accompanied by agreed disarmament or "a limitation of armaments."

The cry of "Never again" was in part responsible for the birth of the League of Nations, the covenant of which, formulated when world conditions were not what they are now, provides among other things for the reduction of national armaments to the lowest point consistent with national safety.

General Swinton is specific on the question of a Disarmament Conference. He says: "I say without hesitation, and at the risk of being "accused of advocating a selfish nationalism, that the law of self-"preservation demands that our first care should be the continued "existence and well-being of that particular Commonwealth of nations "to which we belong.

* * * *

"Apart from the question of degeneration (the result of a prolonged "peace), disarmament, unless universal, may be provocative of war. "At present there is the danger that the States which disarm may be "lulled into a false sense of security, while other States are still struggling "in the birthpangs of a new social system."

He proceeds to discuss the spread of Bolshevism, and presumes that it could not have been present in the minds of the members of the Peace Conference which created the League of Nations.

The important fact from the British point of view, which is our first interest, is that—"Its action appears to be directed mainly against "us. Apart from its onslaught on the mind, amounting almost to a "religious appeal, the Soviet Government shows no signs of neglecting "the argument of force. There can be no talk of abandoning armaments "while Bolshevism is in being and active with its dual threat."

Fortunately we have a Foreign Minister who has no illusions on this point. Last autumn Sir Austen Chamberlain spoke as follows:—

"Our object is not merely that there should be peace, but that all "should feel that peace is secure. Disarmament through security,

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"security through arbitration; arbitration, security, disarmament, are "the common platform of the whole League of Nations. But there is "another disarmament which, indeed, is more urgent, for it is the "necessary preliminary to the physical disarmament of the nations. "It is the moral disarmament of the world."

"This," says General Swinton, "puts the question in its proper "place. Perhaps progress is being made towards this desirable state "of the world, but it has not yet been reached.

* * * *

"Until moral disarmament at least is achieved we cannot regard "the more remote prospect of physical disarmament as a reason for "not preparing for war or for neglecting the study of it."

General Swinton then proceeds to discuss the effect of the recent strides in scientific achievement on the future conduct of war.

Wireless means propaganda made easy. Aviation is still in its infancy. So are submarines. The employment of poisonous gases is a certainty, notwithstanding what may be said to the contrary. The development of mechanical traction is only limited by the cost of experiments in time of peace.

Finally, he sums up as follows:—

"One thing stands out. It is that, however great may be the changes, "however devastating as compared with the past may be the new "weapons, and however feeble may appear the human being in opposition "to the forces to be let loose on him, it is still the man that counts most.

* * * *

"An idea of the future evolution on the technical and material side "and in the actual fighting can be obtained only by a search of the past "for principles, and by an estimate of the direction and extent of the "changes in progress—in other words, by gauging tendencies. If my "reading of the tendencies now discernible is correct, there is every "sign that less and less will strength be said to lie necessarily on the "side of the 'big battalions.' It will be on that of the best trained, "equipped, maintained and led, and most mobile forces if properly "employed. And in our case the question of employment is governed "more by the proper exploitation of sea-power than in the case of any "other nation. For us aviation has increased the difficulties of a would-"be invader, in the old sense of the word, because it has rendered "surprise more than ever difficult of attainment, but it has magnified "the risk of attack in another form, and has put an end to the long-"treasured insularity of our country.

"More than ever will physical action be accompanied by a simultaneous "psychological offensive employed in reciprocal support."

It is satisfactory to hear from undergraduates that the lectures of the new Professor are popular and well attended. If our other great universities would follow the lead of Oxford, future generations will, perhaps, be spared the perils of that amateur leadership which landed us in Gallipoli in 1915 and is now, under the cloak of economy, endeavouring to close our eyes to the possibility of war.

H.B-W.

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THE PERILS OF AMATEUR STRATEGY.

As exemplified by the attack on the Dardanelles Fortress in 1915. *By* LIEUTENANT-GENERAL SIR GERALD ELLISON, K.C.B., K.C.M.G. (Longmans, 1926.) Price 5/-.

EVERY soldier—to say nothing of thinking civilians—should read this five-shilling book, with its valuable preface by Lord Esher. Its publication has already had a result, in that the Imperial Defence College is shortly to be established to deal with the questions of the defence of the Empire. Probably the idea of the college was well on its way to being carried out before Lord Esher's note was written, but the appearance of the book—delayed as it was by the General Strike—was opportune. It would seem as if Lord Esher and General Ellison had been plotting. General Ellison puts up the idea of a Ministry of Defence as a solution of the difficulties. Lord Esher knocks it down and out. He admits that when the Committee which bears his name reorganised the Defence Committee (note the omission of the word Imperial) and created the General Staff (not Imperial General Staff), it failed to foresee that when war broke out the Defence Committee would be swept away altogether, and that the General Staff would be merged in the active command of our armies in the field, and expresses the conviction that if we had possessed in 1914 a Joint General Staff, presided over by such a Minister as Lord Milner, the war would have been shortened by two years.

Two years—think of what that means! No Revolution in Russia—no abdication of the Kaiser—no United States in the War—no abject surrender of the German Fleet—no Wilson at Paris—how many lives saved? But would Europe have been better off?

Lord Esher approves of the idea of a Minister of Defence, but not a Ministry of Defence, and says :—

"The machinery exists in embryo in the admirable Secretariat under "Sir Maurice Hankey, pending the growth of a Joint (real) Imperial "General Staff. Some slight advance was made when the Prime Minister "appointed a Minister under himself as Chairman of the Defence Com-"mittee. But the experiment was not seriously tried. Still, along "that road we are bound to travel, if, as General Ellison contends, "the financial necessities in time of peace, and the demands of strategy "in time of war, are to be complied with in a manner consonant with "a form of government that rests on Parliamentary institutions."

Sir Gerald Ellison was stimulated to write his book after revisiting the scene of the Gallipoli Campaign.

His text is a quotation from "The Life and Letters of W. H. Page" :—

"The horrible tragedy of Gallipoli, where the best soldiers of the "world were sacrificed to politicians' policies."

He sets himself the task of examining the facts to ascertain whether Mr. Page was right. He comes to the conclusion that the statement is in no sense an exaggeration :—

"I hold firmly," he says, "that neither the naval attack on the "fortress nor the subsequent military campaign could, or would, ever "have occurred, had the naval and military experts been called on "to consider the problem deliberately, and in conjunction. In fact, "we know that, when a few years previously this very problem had been

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"submitted to them to report on, their considered opinion had been "so adverse that the Government of the day had been forced to rule "the operation of forcing the Straits altogether out of account."

The point he makes is that "In so far as the higher control is "concerned, our system of conducting war remains to-day exactly "what it was in 1914, and there is nothing whatever to prevent the "astounding happenings of 1915 being repeated on some future "occasion."

Lord Milner states that he agrees with General Ellison's perfectly sound conclusion, while disagreeing with the main argument by which he reaches it.

That main argument appears to be that one man was responsible for the disaster; for, had Mr. Winston Churchill not existed, the Gallipoli expedition would not have taken place. Of that there can be little doubt. But against this we have to remember that had some other than Mr. Winston Churchill been First Lord of the Admiralty in July, 1914, the suggestion of Lord Fisher not to disperse the Fleet after the manœuvres might not have found favour with the Government of the day. Lord Esher is right in deprecating the blame being all put on Mr. Winston Churchill's shoulders. The system was at fault.

The Report of the Dardanelles Commission probably hits the nail on the head. It says:—"What actually happened was that the stress "laid upon the unquestionable advantages which would accrue from "success was so great that the disadvantages which would arise in the "not improbable case of failure were insufficiently considered."

The marvellous thing is, how was it that "this short cut to victory" was allowed to be persevered with in face of the previous decision of the General Staff (and of the Government of the day)?

Plans of campaign—Sir Gerald Ellison points out—take years to think out. Count Schieffen's plan for the next war—with France and Russia in alliance—was first formulated in 1905. Lord Fisher's plan for the redistribution of the British (and French) Fleets was conceived in 1904, in view of the Entente.

It was only in December, 1914, that on his return from a flying visit to France, Mr. Lloyd George sorrowfully realised that the Great War was not to end in six months. It is reasonable to suppose that it was not earlier than December, 1914, that Mr. Winston Churchill conceived, or assimilated, the idea that the deadlock on the Western Front could be solved by an attack on the Straits. On January 2nd, 1915, there came an appeal from Russia for a demonstration against Turkey.

At that time both the experts, Lord Kitchener and Lord Fisher, had secret plans of their own.

Lord Kitchener, with the East always in his mind, had his scheme to cut the Turkish communications with the East from Alexandretta.

Lord Fisher had his plan to envelope the north-western salient of the German Empire from the North Sea and Baltic, as the logical corollary to his strategical scheme of 1904.

Both were experienced fighting men, and did not divulge their secrets.

Suddenly comes "the short cut to victory." Conceived in December, 1914, or even later. Cabinet approval for attack by the Fleet alone on

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January 28th, 1915. Planned by telegraph. It would have required more than Pitt's proverbial luck to have brought off this *coup*. Even the element of surprise was eliminated by a reckless advertisement of our intentions. The amazing thing is, how could Kitchener and Fisher have then been inveigled into the subsequent adventure? General Ellison's book gives an answer, and his quotation (p. 62) from Mr. Churchill's "World Crisis, 1915," p. 172, is significant:—"So obliquely "were these issues presented, so baffling were the personal factors "involved, that the War Council was drawn insensibly and irresistibly "into the gulf."

It is truly an amazing story. Sir Gerald Ellison has unravelled it only in part. It remains for the future historian to probe into the depths when, if ever, the whole of the evidence given before the Dardanelles Commission is published.

It is interesting to note that both Sir Gerald Ellison in this book and Sir Ernest Swinton in "The Study of War" make reference to the study of chess problems when writing of war. There is no doubt that the analogy exists, and that a mind trained by the game of chess is assisted to the solution of the problems of war.

It only remains for the reviewer to urge all young officers to read the book, in spite of the feeling, referred to by Sir Ernest Swinton at Oxford, that the war, and especially the Dardanelles Campaign, is an unpleasant memory, to be forgotten.

There is only one criticism to be made of the form of the book, and it has been made before; and that is that it is a mistake to print many paragraphs in heavy type. However important some of those paragraphs may be to the eye of the author, there are a great many other paragraphs equally important, and they are apt to be overlooked by the reader. It is an axiom that underlining is to be avoided.

H.B-W.

A SHORT HISTORY OF THE BRITISH ARMY TO 1914.

By CAPT. E. W. SHEPPARD, R.T.C. (Constable.) 14s.

THE preparation of a short treatise on a subject of considerable extent demands from the author a clear vision of the object in view. In the present case, where the author deals in some 300 pages with a subject, the standard work on which is to fill 13 large volumes, some such object needs to be carefully considered when deciding what is to be included and what is to be left out. The author in his preface complains, from his own personal professional requirements, of the lack of such a work in up-to-date form, and trusts that the book will be of interest to the general reader and of use to his brother officers. From this we may assume that his object is to produce a book which will be of value to officers in studying, for professional purposes, the growth and history of the Army to which they belong. At the same time it must be sufficiently non-technical to interest the general reader. If this be the correct view, it is to be feared that Captain Sheppard has not achieved his object in either respect. The book is really not a history of the British Army at all, but a skeleton military history of the British Empire;

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a very different matter. An Army is essentially a living organism, and no history of it can be complete which does not deal with the life and soul of that Army, so that one can appreciate once again the spirit which inspired it, and enter into the life which it lived. The book under review is very largely composed of extremely condensed narratives of the many hundreds of campaigns in which the British Army has participated, interspersed at wide inte vals with notes on the characters and capabilities of the more important leaders, and accounts of imaginary battles of various periods, but in one case the account is of an actual battle.

The author's judgments on some of the great leaders are stated with the frankness of a Lytton Strachey, without the reasoned justification which gives such value to the writings of that author. The very attribut s which have led men to be specially respected by posterity are often slurred over. It would almost seem that in his anxiety lest " personalities should rank in popular esteem rather than achievements," the author endeavours to cast down the popular idols from their pedestals. For example, Moore's failures in the Corunna Campaign are specially stressed, while his work as a trainer of troops is barely mentioned, and the revolution in the systems of training and discipline which he fostered is entirely neglected. We also search in vain for any references to Wellington's staff which has been recognised by such authorities as Moltke as the prototype of modern general staffs. At the same time, he very rightly presses the claims for recognition of less known men, such as Amherst, Stringer Lawrence and Moira.

The principal events in the reorganization of the Army are dealt with clearly, but in view of the fact that the book is a history of the Army, some of the details of minor marches and counter marches and actions might have been omitted to make room for fuller discussion of changes in organization, equipment, armament and training.

An indication of the principles which guided the author in his selection of material may be gained from his criticism of Sir E. Wood's " Our Fighting Services." This he finds to be " patchy, many campaigns being dealt with in detail and others omitted or only briefly narrated." In endeavouring to avoid this, which he conceives necessarily to be a fault, Capt. Sheppard has produced a book so full of dry historical facts that it loses the interest of the general reader without giving sufficient information on any one point to the professional student.

The arrangement of the campaigns in the book, admittedly a difficult problem, seems to have been dealt with more from a geographical point of view than from the point of view of a history of the whole British Army. It therefore fails to show how the inter-relation of various campaigns affected the problems which faced the statesmen and the Army as a whole.

The author has dealt with a great mass of information, and his style is always pleasant, and at times quite stirring. We can only regret that he has not given us a more living history of that very human organism which is his theme. A laudable endeavour to show only such detail and names in his maps as are mentioned in the text has been overdone, so that many of the sketches which illustrate the book are of little value.

R.P.P-W.

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TALKS ON LEADERSHIP.

By "BASILISK," R.A. Institution, Woolwich. (Second Edition, 1926). Price 1/4 post free.

This little pamphlet is intended by the author for those to whom leadership does not come naturally, but it is doubtful if even the born leader would not benefit greatly by a study of its 38 pages. The tyro in the art of command will find much valuable advice, and the experienced commander will find ideas crystallized and expressed delightfully, so delightfully that those whose duty has taken them away from direct command of men will itch to get back once more into closer touch with Tommy Atkins. Though the author finishes with three pages of Dont's, his advice is chiefly positive. He divides the book into 4 chapters. No. I deals with general principles, and these may be summed up in the French proverb "Tel chef, telle troupe." Chapter II treats of dealing with men collectively. In this the author's hints on giving instruction and lectures will prove invaluable. Those who know the S.M.E. lecture theatre will smile at the advice: "It is better that the men should be so comfortable that there is even a tendency for them to go to sleep, than that they should have to struggle to turn their minds from their physical discomforts and concentrate them on the lecture." The art of giving orders and the subject of Esprit de Corps are well treated. Chapter III deals with men individually, the keynotes being "sympathy" and "justice." Last of all come the "Don'ts."

We can imagine no better gift to a young officer going to his first unit than this excellent little book.

R.P.P-W.

THE WORK OF THE SURVEY OF INDIA IN THE GREAT WAR.*

IN peace time the Survey of India employs about thirty Royal Engineer officers and a smaller number of officers of the Indian Army. This great Survey has always been connected with the Corps since 1764, when James Rennell was commissioned as ensign in the Bengal Engineers and was, at the same time, appointed Surveyor-General of the East India Company's dominions in Bengal. We notice, by the way, that the device on the title-page of the book under review bears the date 1767, and the names of Lambton and Everest, but not of Rennell. The department had thus, when the war broke out, the benefit of the accumulated traditions and experience of a hundred-and-fifty years, and it is quite safe to say that no organisation could have coped with the immense difficulties of mapping the war areas, chiefly in the tropical and sub-tropical regions of the Near and Middle East, in the very successful way recorded in this book, if it had not had this mass of experience to draw upon.

The volume in question describes the surveys and explorations carried out by the Survey of India, during the operations in Mesopotamia, Kurdistan, Macedonia, Arabia, Persia, Palestine, East Africa and

* Records of the Survey of India, Vol. XX. The War Record, 1914-1920. Published under the direction of Colonel Commandant E. A. Tandy, R.E., Surveyor General of India. Dehra Dun, 1925. Price 3 Rupees, or, 5 shillings and 3 pence.

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Afghanistan. In the Preface, the present Surveyor-General remarks that "these explorations and surveys were accomplished in the face of many difficulties and in every variety of terrain, from the icy highlands of Central Asia to the waterless deserts of Persia and Arabia." But, from the nature of this case, most of the space is devoted to work in Mesopotamia and Persia, which, in fact, occupies four-fifths of the account; a few pages only, in each case, sufficing for the war surveys in Macedonia, Sinai and Palestine, East Africa and the North-west Frontier. In fact, the Survey of Egypt was actually responsible for the mapping of Sinai, Palestine and Syria. Throughout the whole of the war the Department was administered by Col. Sir Sidney Burrard.

At the outbreak of the war the strength of the Survey of India was 55 Imperial officers, 148 Provincial and 37 Upper Subordinate officers. Before the end of 1914, twenty-seven Imperial officers had reverted to ordinary military duty, leaving half the original number to provide for the survey requirements of the war. And this will serve to give an idea of the difference in the character of the problem which was set before the Survey of India, from that which confronted the Geographical Section of the General Staff and Ordnance Survey in the western theatre of war. In the latter case, owing to the immense size of the armies and the stationary and intensive nature of the fighting, the utmost elaboration became necessary, and we find a large survey establishment employing, at its maximum, some 250 officers and some 4,000 men. Matters in Mesopotamia had, of course, a difficult complexion, and we may note that the Basrah Party in September, 1915, was composed of only six officers and 12 subordinates; and, after the occupation of Baghdad, the Survey Directorate consisted of 15 officers and 30 subordinates, in addition to a Compilation Section, with Army Headquarters, of five officers and 60 other ranks. The Survey Directorate was under the command of Col. F. W. Pirrie, I.A. The Compilation Section was under the command of Major C. P. Gunter. Up to July, 1916, the surveys were carried out chiefly in the neighbourhood of Basrah, and along the banks of the Tigris; by the end of that month some 7,000 square miles of ½-inch work had been completed, with an additional 2,000 square miles of rougher reconnaissance surveys. For the next 20 months the surveys were mainly in the regions near Baghdad and Kirmanshah, with isolated areas elsewhere. And, after March, 1918, the surveys were chiefly in the region of Mosul, and in areas joining up previously executed work. By this latter date, in Mesopotamia and Western Persia, a great block of accurate mapping had been accomplished, stretching from the Persian Gulf to Amadia, and from Hit to Kirmanshah, with an outline as far as Tehran. We may picture it as a block of country 500 miles long and 300 miles wide, but of somewhat irregular shape. Whatever else the war may have done, it has greatly increased our knowledge of the geography of this region.

Lt.-Gen. Sir Percy Lake, writing in August, 1916, after expressing his appreciation of the energy and zeal shown by Colonel Pirrie and his staff, remarked that, "A noticeable feature of the work has been the entire absence of friction with the peculiarly uncertain elements of the population, settled and nomad, of the tracts surveyed; a fact which

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speaks as highly for the professional advice and assistance rendered by the Political Department as for the tact and intelligence exercised by the Survey Staff."

The Surveyor-General, in his Preface, draws particular attention to the circumstances attendant upon the long march of over 20,000 men to the Dujailah Redoubt, on the night of the 7th March, 1916, expressing the opinion that " if the opportunity presented by this very successful night-march had been promptly seized, Kut would almost certainly have been relieved." Further on, in the body of the book, it is stated that the map used for this operation was compiled from various sources, from the old pre-war river maps, reconnaissances, air reports and sketches. It is asserted that the official accounts " tend to give the impression that the inaccuracies of the map prejudiced success. This is not the case, as a critical study will show." A capable and experienced Survey officer guided the force ; the column was accurately led to the point laid down for deployment. This officer does not believe " that any delays in the march, nor any inaccuracies of the map had any effect whatever on the arrival of the head of the column at the time or place appointed nor on the subsequent disaster." Military historians, please note.

It is difficult fully to realize the condition under which much of the surveying was carried out. The floods, which obliged the surveyors to set up their plane-tables in the water, the legs lengthened by bamboos, the surveyors themselves standing in *ballams ;* the mist in the early morning, the dust, the haze, the mirage ; the suspicious attitude of some of the inhabitants ; the storms in the water areas ; the reeds, sometimes twenty feet high, in going through which only a time compass sketch could be made ; and the heat. As to the heat, it is stated that, when Col. Pirrie guided some armoured cars for sixty miles across the desert, in July, 1917, the shade temperature was 126°, and that during June, July and the first half of August, of that year, the heat was so intense that neither our Army, nor the enemy's, undertook any extensive operations, but " the surveys were continued in spite of the heat."

A point of considerable technical interest is that, at Aleppo, the Mesopotamia triangulation joined on to that carried out from Egypt, so that there is a continuous triangulation, via Aleppo, between the Persian Gulf and the Nile. The discrepancies found at Aleppo, which are partly due to the use of different initial data, and partly also due to the use of different figures of the earth, are not large ; namely, about 8″ in latitude, 1″ in longitude and 30 feet in height. And we may put the direct distance from Aleppo to the Gulf at about 800 miles, and from Aleppo to Cairo at about 600.

The work in N.W. Persia joins on to that in Mesopotamia, and was carried out by a small survey party, under the command of Capt. W. E. Perry, R.E., attached to the Russian Army, with headquarters, early in 1917, at Hamadan. The report on this work gives an interesting view of the almost complete want of discipline in the Russian forces in May and June, 1917. "About the 8th June...the Russian rank and file decided to quit the Diyalah front, and forced the hand of the divisional general. . . . The G.O.C. and the officers generally were

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in a hopeles position. . . ." The survey party found it impossible to return at once to Baghdad, but had to retire into Persia with the Russians. After many difficulties and some fighting with the Kurds in the Chehar Zabar Pass, Kirmanshah was reached on the 24th June. A good deal of plane-table work was done in September, October and November in the neighbourhood of Kirmanshah, and a junction was effected with Colonel Ryder's Turco-Persian boundary commission survey of 1913-14. This party returned to Baghdad in January, 1918, having surveyed about 4,500 square miles on the ½-inch scale. Shortly after this, a survey detachment, under Lt. D. K. Rennick, was sent to accompany General Dunsterville's force on its way to the Caspian. Then, in February, 1919, Major Rich went to Tiflis to organise a drawing office for advanced G.H.Q., Black Sea Army, an office which was staffed with six Russian ladies and one man! "By the end of the first month the ladies were all very satisfactory 'draftsmen,' good hand printers, and could transliterate names." This office was closed down in September.

As to North-East Persia, in September, 1918, a survey party, consisting of six officers and 32 surveyors and computers, under Colonel H. L. Crosthwait, R.E., was sent to map a large area in the east and north-east of this country. Existing maps of this region were very faulty and the whole survey had to be undertaken *ab initio*. This party travelled to the railhead at Duzdap and then proceeded by road, for 300 miles, to Birjand. The work was carefully organised and there was no opposition; some 40,000 square miles was completed by June, 1919.

A "Miscellaneous" section of the book deals with the work of Survey of India Detachments in Macedonia (under Col. H. Wood, R.E.), Sinai, Palestine and East Africa. As to Sinai and Palestine, the Survey of India was not officially concerned with the mapping of those countries, but Major J. D. Campbell, R.E., was attached to the 7th Field Survey Company of the E.E.F. Excellent work was done on the 1 : 40,000 scale, and various reconnaissances were made in Sinai. It should, perhaps, have been mentioned in the report that Northern Sinai had been completely mapped on the 1:125,000 scale and reconnoitred, *before the war*, by the joint efforts of the Geographical Section of the General Staff and the Survey of Egypt.

Perhaps enough has been said to give an idea of the contents of this interesting War Record of a Department which has never failed, in its long war history, to justify its high reputation. C.F.C.

ENGINEERING SURVEYS.

SURVEYING. By W. NORMAN THOMAS, M.A., D.PHIL., M.SC. B.SC. (Edward Arnold and Co. 1926.) Second Edition. Large 8vo.; 548+viii; 298 illustrations and diagrams. Price 25s.

JUST as the term "electrician" may be applied to the necessary individual who attends to the domestic uses of electricity, or to a Lord Kelvin, so the term "Surveyor" may be used of one who sets out the foundations of a house, or to the explorer of a continent, or the in-

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vestigator of the figure of the earth. It is, therefore, desirable, in reviewing a book on surveying, to indicate its scope and the particular readers for whom it is written. Mr. Thomas, in his Preface, states that the aim of the author " has been to present the subject in such a form as will be useful to students of Civil Engineering at Universities and Technical Colleges, and to those who are going up for examinations held by the Institution of Civil Engineers and the Surveyors' Institution, and to Civil Engineers and Surveyors who are already in practice " ; the word Surveyor, in this sentence, meaning the civil surveyor who deals with houses and estates, valuations, the setting out of plans, and such very necessary matters which come generally under the consideration of the Surveyors' Institution.

The first edition was published in 1920. In this second edition the section on Aerial Survey has been re-written and some notes have been added on the Prismatic Astrolabe and Wireless Time Signals. In the body of the book there are, as before, chapters on Spherical Trigonometry and Field Astronomy. But, in the main, the book is devoted to those methods of surveying which may be useful to the engineer, and the whole tone and character of the book is conditioned by the engineering outlook.

It fulfils its purpose well, and engineers who may have large scale surveys to undertake will find it a useful book of reference. It will be equally useful to engineering students ; and, indeed, all interested in surveying, will find in the book much to interest them. It is well got out and is generously illustrated. An excellent feature of the book is that the author has been careful to point out and discuss the errors to which the various surveying operations are liable. Thus we have a discussion of the errors which occur in chaining ; a discussion of traverse errors, with the derivation of Bowditch's Rule for the adjustment of traverse errors ; a discussion of levelling errors ; and so on.

As the book is, no doubt, intended chiefly for British engineers, Ordnance Survey practice is freely quoted ; a very reasonable thing, in view of the large use made of ordnance maps by engineers and surveyors in this country. We notice on p. 202, the statement that, " It is expected that the field work of the geodetic levelling [of England and Wales] will be completed early in 1920." Now, as the date of the second edition of the book is 1926, this sentence should have been revised ; for the Report on the *Second Geodetic Levelling of England and Wales* was published in 1922, the work itself having been finished in 1921. Mr. Thomas would have found some matters of interest in the report.

On p. 385, an account is given of the measurements in 1783 (it should be 1784), and in 1791, of the Base on Hounslow Heath, and the remark is made " bases of verification were measured at the following places, and the measured lengths compared with the calculated lengths :—

Salisbury Plain Base.
King's Sedgmore in Somerset.
. .....
Lough Foyle in the North of Ireland.
Lossiemouth on the Moray Firth (1909-12)."

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This might, and probably would, give the impression that the fundamental base is that measured on Hounslow Heath, and that the other bases were measured to ascertain the amount of error accumulated. Actually, the lengths of the bases at Hounslow Heath, Sedgmore, Misterton Carr, Rhuddlan Marsh, and, we may add, Romney Marsh, do not enter at all into the computation of the Principal Triangulation of this country. The Triangulation depends on two bases: that measured on the shores of Lough Foyle in 1827-28 and the Salisbury Plain base of 1847.

Perhaps the least satisfactory chapter is that on Plane Table Surveying; and this chapter appears to the reviewer as unsatisfactory, not because it is erroneous, but because it gives the impression that plane-tabling is a difficult art. The diagrams are really alarming, and are the sort of thing that would be worked up for an examination and that examiners would delight in; it would have been better to have relegated them to an appendix, or to have put them in a note at the end of the chapter. Generally, in fact, there is a certain amount of excellent matter which is not essential for the practical man, and might, perhaps, have been printed in smaller type with advantage.

There is a small slip on p. 109. The Arc of Meridian in question was measured not "north of Lake Tanganyika," but in the Semliki-Ruwenzori region, to the west of Lake Victoria. In the account given of the determination of the Meridian no mention is made of that most useful method, the observation of the altitude of an east, or west, star, near the Prime Vertical.

These, however, are small matters. The book can be recommended, not only to engineers, for whom it was primarily written, but to all interested in the subject. It contains much valuable information, and is written in an excellent critical spirit. C.F.C.

RAILROAD CONSTRUCTION.

By WALTER GORING WEBB. 8th Edition. (Chapman and Hall.) Price 25/-.

THE necessity for the issue of a new edition of this work, after a period of four years, is further evidence of its usefulness and popularity. It continues to be one of the leading treatises giving in a small compass a general survey of all points affecting the design of railway location.

The amendments in the new edition, which occur on fifty-four of its pages, are chiefly concerned with the present recommended practice of the American Railway Engineering Association and post-war operating conditions and costs. Most of these alterations do not call for individual comment, but a list of them will be useful to those who possess copies of the previous (7th) edition.

Chapter II (*a*) Correction of the arithmetical constant in formula (30), for superelevation, from 0.0000572 to 0.0006865.

(*b*) Superelevation in practice.

(*c*) Minimum length of transition curves.

(*d*) Practical formulæ for the 10-chord spiral.

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Chapter	III	(*a*) Classification of railways transferred from Chapter VII.
		(*b*) Sodding of slopes.
Chapter	IV	(*a*) Sizes of stringers for wooden trestles.
		(*b*) Sizes of bridge sleepers and fastenings for timber guards.
		(*c*) Working stresses in timber.
		(*d*) Loads on various parts of trestles.
		(*e*) Numerical example of design.
		(*f*) Commercial sizes of timber.
Chapter	V	(*a*) Tunnel cross sections.
		(*b*) Tunnel linings.
Chapter	VII	(*a*) Classification of ballast.
		(*b*) Specifications for ballast
Chapter	IX	(*a*) A.R.E.A. 150 lb. rail.
		(*b*) Length of rails.
		(*c*) Cant of rails.
Chapter	X	(*a*) Maintenance of rail joints.
		(*b*) Fish bolts.
		(*c*) Anti-creep devices.
Chapter	XII	(*a*) Platform surfaces.
Chapter	XV	(*a*) Chilled cast iron wheels.
Chapter	XVIII	(*a*) Tractive effort at various speeds of locomotives using superheated steam.
Chapters and	XIX XX	(*a*) Post-war operating conditions, operating ratios and costs.
Chapter	XXIII	(*a*) Variation of draw bar pull due to changes of speed and its application.
		(*b*) Operating costs of pusher grades.
Chapter	XXIV	(*a*) Changes of grade as effected by (*a*) in Chapter XXIII above.

On page 443, paragraph (*f*), line 5, the word "vaporized" is used instead of "condensed." In line 8 of the same paragraph "vapor" should be taken as meaning condensed steam.

On page 347 the following sentence near the bottom of the page is worthy of the greatest attention. "This is a further illustration of the futility and even danger of quoting costs, or even *unit* costs, except to show the method of applying the particular unit costs which are locally applicable to any individual case." In this connection it should be noted that all the costs in Chapter III, "Earthwork," are the same as those which appeared in editions published before the war. These figures would have been more generally useful if converted to time units for men, animals and equipment and for expendable materials to which local costs could be applied for individual cases.

The instructions for the use of the "automatic slope stake rod," given on pages 116 and 117 of both the 7th and 8th editions, can be greatly simplified, with elimination of considerable arithmetic, if the rules for its use are amended to read—

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(1) When setting slope stakes at the top of a *cutting*, read on the face of the rod on which the graduations increase from *top* to *bottom*, and when setting slope stakes at the foot of a *bank*, read on the face of the rod on which the graduations increase from *bottom* to *top*.

(2) Having set up the level, place the rod on ground level on the centre line and adjust the rod-tape so that its reading is equal to the depth of cutting or embankment at that point. Other readings at any points on the ground will then give the heights of these points above formation level in cuttings or below formation level in banks. As the special distance tape gives the same information regarding the side slope of the earthwork coincidence of readings will determine the correct positions of slope stakes.

(3) In sidehill work the above procedure still holds if the centre line and slope stake both refer to cutting or both to bank. When the slope stake is at the top of a cutting and the centre line is on a bank or when the slope stake is at the foot of a bank and the centre line is in cutting, use the rod in the position appropriate to the nature of the earthwork at the slope stake and consider the centre line depth as negative, *i.e.*, the reading through the level, when the rod is on ground level on the centre line, should be 20 minus the depth. When the reading on some other point on the ground becomes zero the earthwork will change from bank to cutting or *vice versa*.

(4) Record in the notes the height of the slope stake above or below formation and its actual distance from the central line as read on the normal side of the tape. A stake should be put in where change from bank to cutting occurs, and duly recorded.

W.G.T.

THE BOOK OF THE LIGHT CAR.

By E. T. BROWN. (Chapman, Hall, Ltd.) Price 7s. 6d.

THE author has set out to explain as simply and briefly as possible the construction of the modern light car. He follows this with advice on the best type of car to buy, how to maintain and drive it, together with hints on how to enjoy a motoring holiday.

Section I deals with the internal combustion engine, 4-stroke and 2-stroke, giving the cycle of operations, etc. There is no new subject matter in this Section, but it is notable that nothing is said about valve timing, or reasons for early opening of exhaust, valve overlap, etc.

Section II deals with fuel supply, lubrication, ignition, transmission, cooling, steering, wheels, springs, etc. The explanation as to how the proportions of air and fuel are regulated by different forms of carburettor are sketchy, and could not convey much to a novice. The section on "Ignition Secrets" is no better, and no worse, than has been published in many other handbooks. The same may be said of most of the rest of this section.

In order to dry the interior of the water jacket and pump during cold weather, the author recommends draining off the water and then

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running the engine. This seems an unnecessary precaution, since nearly all modern cars have special drain cocks for pumps, and pockets in the cooling system.

Steel cement is recommended for sealing cracks caused by frost in cylinder water jacket. A weld will always make a better job; such repairs can now be cheaply and efficiently carried out by specialists in this kind of work.

Copper rivets are recommended for the fastening of brake linings to brake shoes. The use of aluminium rivets for this purpose is now almost universal.

Section III deals with the choice of a new car, and the various advantages and disadvantages of purchasing a new or second-hand vehicle.

A section is devoted to running costs. The calculations on this subject appear to be on the optimistic side.

Section IV treats of the care of the car, and contains a "Trouble Chart." Various causes of trouble are tabulated, and a reference made to the paragraph where the remedy is to be found in the text.

Some of these references are not very helpful; *e.g.*, a broken piston ring is given as a possible cause of engine stoppage, and a reference made to paragraph 22. This paragraph merely says that a broken piston ring may be a cause of scoring the piston, and that the remedy is to dismantle the engine. No hint is given as to what noises or symptoms indicate a broken ring.

The sections on overhauling assume a higher degree of mechanical knowledge than could be gained from a study of the previous chapters.

The sections on the electrical equipment are rather too general to be of great use. Very little useful advice is given on the care of the battery.

The patching of tyres, and the carrying of a tyre garter, presumably in place of vulcanizing, and the carrying of a spare wheel are recommended. Both patches and garters are abominations in the opinion of the reviewer.

Section V deals with the art of driving; double de-clutching, etc., is explained, cross-road risks, skidding, and driving in fog are also touched on,

Section VI gives a number of facts that should be known by all motorists. Most of these are almost self-evident. There are many illustrations of doubtful types of light car, but these are merely pictures. and show nothing of the mechanical details of the types selected.

Generally speaking, the book is amateurish, and there is little in it which has not appeared in print many times before. G.C.G.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

January, 1926. In the second number of *Verdun—Le Premier choc à la 72e Division*, Lieutenant-Colonel Grasset gives a vivid description of the original onslaught on February 21st, 1916. The sudden change from peaceful conditions to the unparalleled violence of the opening bombardment is most realistically described, and the author succeeds

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in bringing out the terrible uncertainty and chaos which were nearly always a characteristic of the early stages of a great trench warfare attack. The climax was reached when the Commander of the 72nd division was suddenly ordered to move his headquarters forward during the day, further dislocating the organisation of the sector and crowding up an already harassed infantry brigade headquarters. The number closes with the various commanders in a state of suspense, ignorant of their losses both in terrain and troops.

Lieutenant-Colonel Bailles, " Directeur du Génie " at Nantes, completes his *Essai sur l'Emploi tactique du génie* in this number. The role of divisional engineers in attack and defence is discussed, the general conclusions being similar to those arrived at in our own Army, with the exception that the author envisages the C.R.E. of the division, accompanied by the bulk of the divisional engineers, moving with the advanced guard, in readiness to undertake any engineer work which may arise. It would appear that there is a risk of divisional engineers being used up at an early stage of the battle under this system. The article concludes with a discussion of the effect of track vehicles on demolitions.

L'offensive de Bonaparte contre l'Angleterre begins in this number with a preliminary discussion of Bonaparte's strategy and a description of his voyage to Egypt in 1798, during which he was successful in evading the attentions of Nelson and the British Fleet. It is interesting to see how, even in the days of the French Revolution, an occupation of Egypt by France would have proved a menace to our far Eastern possessions; Bonaparte's object in invading Egypt was to attain a secure base for an attack on India. The manœuvres of the French and British fleets are illustrated by a sketch map.

Une attaque de nuit au Maroc, by Capitaine Damidaux, is chiefly interesting in the description of the methods by which the attacking troops were able, by careful preparation and minute precautions, to surprise the Rifis and occupy their positions in sufficient strength to beat off the inevitable counter-attacks. The sketch maps are rather meagre and give an inadequate idea of the country.

In *Dressage des Cadres à la recherche du renseignement*, Lieutenant-Colonel Paquet describes the preparation of an exercise carried out with the object of training the intelligence organisation of a division in the field. The various intelligence staffs and personnel, together with sufficient signals and aircraft are involved, the whole operation being controlled by a directing staff and made realistic by the employment of a skeleton enemy. The most interesting part of the article is that devoted to the action of the skeleton enemy, particularly with a view to producing appropriate air reports. The importance and difficulties of umpiring are fully discussed.

In *Les cables téléphoniques souterrains*, Capitaine Jaubert discusses the inadequacy of the present overland system of telegraph and telephone lines, and gives a forecast of future developments in underground electrical communications.

February, 1926.—In the third number of *Verdun—Le Premier choc à la 72e Division*, Lieutenant-Colonel Grasset deals with the night of February 21st-22nd, and the various attempts at counter-attack made

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by the 72nd division. In particular, a brilliant little operation conducted by Lieutenant Robin, with the remnants of a company of the 59th battalion, succeeded in clearing the northern outskirts of the Bois des Caures. All efforts to re-capture the Bois d'Haumont, which had been lost in the original onslaught, were unsuccessful. Throughout this period the inadequacy of the signal communications are most apparent, especially when all the heavy guns of the 30th Corps were placed under one commander at midnight, although adequate communications were not available. The sketch map illustrating this period is to be found in the March number.

L'offensive de Bonaparte contre l'Angleterre is concluded in this number. The author points out that, once the French Army had landed in Egypt, a fleet in being was essential to the success of Bonaparte's plans. He suggests that Admiral Brueys should have occupied a secure base on the flank of the communications between Toulon and Alexandria, *e.g.*, at Corfu, with the view of changing the French base from Toulon to Venice. By moving to Aboukir Bay, Brueys laid himself open to destruction by Nelson, thereby making the realisation of Bonaparte's plans impossible.

Commander "X" begins an interesting article entitled *Réflexions sur la Compagne Riffaine*. He describes the methods employed by Abdel Krim in the subjugation of the tribes under French influence and points out the alternative methods for opposing the Rifi chieftain. Owing to the failure to provide adequate support for the friendly tribes in the early stages of the campaign, the employment of strong forces of all arms, especially tanks, became necessary to crush the Rifis.

Lieutenant-Colonel Paquet completes his article, *Dressages des Cadres à la Recherche du Renseignement*, with a detailed description of the methods employed to train the intelligence organisation of a division (particularly the "2e Bureau") during an exercise on the ground. The control of operations by the directing staff, with particular reference to the methods of obtaining reality in the photographic reconnaissances ordered by divisional headquarters, is well worth study. The value of this type of exercise depends almost entirely on the skill of the umpires and the handling of the skeleton enemy.

In *Une Opération de Guerre de Montagne* (*Carpathes*, 1916), Capitaine Flipo describes a series of actions between the 61st Austrian Division and the 7th Rumanian Division, taking place from October 15th to 17th, 1916. The Austrian troops were unaccustomed to mountain warfare, while the Commander of the 14th Rumanian Brigade, which was chiefly involved, had been accustomed to the theatre of operations throughout his service. The result was the defeat of the Austrians, rendered incomplete, however, by faults in execution on the part of their adversaries. The interest of the article is rather spoilt by the inadequacy of the sketch maps.

Commandant Besnard, in *Synthèse du Mouvement*, points out how mobility has always been a characteristic of the operations of the great commanders. He then discusses the various means of locomotion of modern armies, from the men's muscles to the tank, and continues with a description of the various phases of movement, leading up to the

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encounter battle. Movement in battle is discussed in the next number.

March, 1926.—The fourth instalment of Lieutenant-Colonel Grasset's *Verdun—Le Premier Choc à la 72e Division* describes the resumption of the German attack on February 22nd. It was not till the evening that the defenders were able to stem the tide by the occupation of the second main line of resistance, two regiments having been sent up as reinforcements by Corps headquarters. The outstanding features of this phase are the heroic but unsuccessful defence of the Bois des Caures by Lieutenant-Colonel Driant with the remnants of the 56th and 59th Battalions, and the difficulties of General Bapst, commanding the 72nd Division. Orders from higher authority, to the effect that not an inch of ground might be given up, fettered his initiative; when he considered it essential to evacuate Brabant on his left flank he was unable to obtain a definite authority to do so; and he had to move his headquarters again owing to lack of con munications at Vacherauville.

Commandant "X" completes his *Réflexions sur la Campagne Riffaine* by an interesting discussion of the political and military organisation best suited to the local conditions. He considers that Marshal Lyautey's principle of combining the political and military direction of the various districts is thoroughly sound, and that an organisation of mixed brigades would allow of greater mobility and freedom of action than the more rigid divisional system introduced by the appearance of the Metropolitan Army.

La Prise de Contact et l'Engagement, by Capitaine Nalot, is really an expansion of the principles laid down in Field Service Regulations with regard to the preliminary stages of the modern battle, together with a comparison with the doctrine of the pre-war regulations.

Les Debarquements Alliés aux Dardanelles, by Commandant Desmazes, gives an excellent outline of the events leading up to the operations and of the original landings. The author offers no criticisms, but the facts are presented clearly, and a paragraph on the action of the Turkish forces during the various stages of the operation is of particular value.

Commandant Besnard completes his article, *La Synthèse du Mouvement*, by a discussion of the principles of fire and movement as applied to the present day tactics. The article concludes with the transition from the unbroken firing line to the modern methods of attack by small groups at irregular intervals, caused by the development of automatic weapons.

Les Transmissions au Maroc describes the development of Signal communications during the operations against the Rifis. A considerable portion of the article is too technical to be of general interest, but it is instructive to note the great lack of communications at the outset of the campaign and the enormous strides that were made as the supreme importance of communications in such dispersed operations became evident.

REVUE DU GENIE MILITAIRE.

April, 1926.—*The Launching of Metal Road Bridges.* The conditions for launching a road bridge differ from those for a railway bridge in that the latter can usually employ a launching nose—whereas with the

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former the slope of the approach and sharp curves frequently preclude this method.

The " Pigeaud " bridge of the smaller type (up to 37.5 metres span) in use in the French Army is assembled across the gap by means of a footway slung on cables. This method can be used for bridges of one or more bays, but is not so convenient for the heavier bridge of 51 metre span—for which four methods are discussed :

(1) A constructional bridge of light piles or trestles ;
(2) Trestles erected on floating supports ;
(3) Derricks and tackle.
(4) A combination of (2) and (3).

These methods are discussed in detail and the application of No. 3 to the Hopkins Bridge is noted with approval and formulæ for calculations are given.

The writer sums up that it is undesirable for the Engineer units to be encumbered with special equipment for the erection of bridges, and considers that a suitable collection of winches, blocks, tackles and derricks should enable any type of bridge to be erected, repaired or removed in any position.

The Bamboo. Points out the merits of the material and gives figures for compression and transverse strength of poles of the male bamboo and the value of the female bamboo for transverse strength and as a material for a raft.

The latter is useless as a pile and has little or no resistance to compression.

The Demolition of eight Chimneys. Details of the chimneys and the method of destruction, time and labour involved.

" Données Numeriques." Details of time, material and labour on various works executed by units of engineers.

Ordonnance du Roi. The text of a Royal Order in 1744 creating the " Corps du Genie."

May, 1926.—*Study of the Stresses on a Cable laid across a River.* An elaborate calculation ending with the statements that conditions of the river bottom usually render such calculations useless and that the greatest stresses are incurred in the process of laying the cable.

The Organisation and Operation of Military Workshops in the Field. The author affirms that good operation follows early from a satisfactory organisation ; he points out the many difficulties which distinguish a military workshop in the field from a civil shop, together with the advantages, and gives advice that would be useful to any Officer starting or operating a military workshop.

June, 1926.—*The Theory of Land Mine.* A theoretical investigation of the height and distance of projection of soil and of the shape of the projected mass from a mine.

New Locomotives for Express Trains. A description of 2-4-1 engines adopted for heavy expresses on the French Railways.

Pack Transport of Pile Drivers. A description, with illustrations, of a method designed for carrying the equipment type pile driver on mule transport—one mule hauled a two-wheel truck carrying the monkey.

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The load (including harness) for eight other mules was about 150 kg. each mule.

A 66-foot Single Span Footbridge. Built of light spars, not exceeding 5 to 5½ inches butt diameter, and wire, and erected by 120 men in 24 hours.

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H.G.K.W.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1926. Tome I. Nos. 1-3 inclusive.)—*Les Opérations de l'Armée Belge* (1914-1918). On the evening of October 8th, 1914, the situation at Antwerp, as disclosed in reports reaching the Fortress Headquarters, was such that General Déguise felt justified in authorising the abandonment of the "Second Line of Defence," but, before sanctioning this course, he held a conference at his Headquarters at which the Commandant of the "Second Line of Defence" and the Commander of the Royal Naval Division were present. Further reference is made in the original article (No. 1 of the issue) to the part played by the R.N.D. at this time, and it is stated therein that, although it was known at Fortress Headquarters that General Paris had during the day been in telephonic communication with London, General Déguise was given no information as to the tenour of what had passed during the conversations between Antwerp and London, nor was he aware of the nature of the instructions left with the Commander of the R.N.D. by the First Lord of the Admiralty on his departure for England. We have here another unfortunate example of the difficulties which arise, as they are bound to do, when two or more authorities attempt, independently of one another, to conduct military operations in a restricted area; from every point of view, the wisest of all courses would have been to have given General Déguise supreme authority in the Antwerp zone and to have allowed him to conduct the operations for the defence of the Citadel as seemed to him best in the light of the "intelligence" reaching his Headquarters. In the actual circumstances, nothing could have prevented the Fortress falling eventually into German hands, but it could not then have been suggested that the surrender was accelerated by this or that independent act of an Ally.

The measures taken for the withdrawal of the R.N.D. and the Belgian 2nd Division are described; in connection therewith instances of bad staff work are brought to light; fortunately, no very serious penalty had to be paid therefor. The Germans seem to have still remained unaware of the fact that the Anglo-Belgian troops had begun to abandon the defence of the outer positions of the Fortress. In view of the decision to withdraw from the "Second Line of Defence," steps were now taken by General Déguise to transfer his Headquarters to Calloo, on the left bank of the Scheldt. At this time some of the forts of the principal line of defence were still holding out; no modification having been made in the orders issued on October 6th, the Commanders of these works had to act independently of one another and to the best of their own judgment. The German effort was now being directed chiefly

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against the Anglo-Belgian positions in the 3rd and 4th Sectors of Defence, and on October 8th the enemy's main attack was being pushed against the works covering the bridge over the Rupel at Boom.

Particulars of the situation in the forts of the principal line of resistance are given in No. 2. A description is also given of the old enceinte designed by Brialmont and its condition at this date. Orders were issued at 6.30 p.m. on October 8th by the Commandant of the Enceinte to Commanders of the two Sectors under him to put up an obstinate defence on the old ramparts of the city. Instructions had already been issued for the demolition of the temporary bridges at Sainte Anne and Burght as soon as the withdrawal of the R.N.D. and the Belgian 2nd Division, *via* these bridges, had been completed; the necessary orders had also been given for the destruction of the drawbridges, etc., on the roads leading through the ramparts. It was intended that the fortress troops should, when the necessity arose, be transported across the river in tugs, ferry-boats and other craft collected for the purpose—chiefly at Lillo. However, owing to the hurry and confusion in which the retreat of the Belgians was carried out, the demolition work was not done systematically and with thoroughness; in consequence, several bridges, etc., were left intact and became available for the use of the enemy.

At 8 p.m., on October 8th, General Déguise and his Staff crossed the river and the Fortress Headquarters were now established at Calloo, between the 5th and 6th Sectors which formed the retrenched camp on the left bank of the Scheldt. There seems to have been no end to the chapter of accidents connected with the defence arrangements; General Déguise's difficulties appear to have been increased owing to the fact that the Fortress Supply Officer closed down his office in Antwerp and moved his headquarters to Ostend; he acted under instructions issued to him direct by the War Minister, of which intimation was not passed on to the Fortress Headquarters.

A description of the retrenched camp on the left bank of the river—which was the weakest part of the Antwerp defences—and the situation at this time in the 5th Sector—are dealt with in No. 3.

La Bataille des Frontières. The articles under this title in these three numbers are contributed by Major van Overstraeten and deal with the operations on the French frontier at the commencement of hostilities in 1914 and are of considerable interest.

La Problème de la Direction de la Guerre. In this article, contributed to No. 1, Captain-Commandant Dendal deals with the conditions under which a modern war between great nations is conducted. He points out that the considerations which now affect military operations are no longer confined mainly to the factors associated with the field of battle, but those lying in the political, economic and social domains also come prominently into play and create most powerful influences in military plans. A modern war is waged, he reminds us, on four fronts, viz., *le front militaire, le front diplomatique, le front économique,* and *le front intérieur.* The article is a valuable contribution to military literature.

Le rôle et le fonctionnement des assemblées parlementaires en temps de guerre. Captain-Commandant Dendal is also the author of the

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article under this title appearing in No. 3; the theme of the same is really a continuation of the subject dealt with in the other article by him previously mentioned in this notice. Complex questions relating to the functions of a Government and a Legislature and the part they are required to play after the outbreak of hostilities, and during the continuance of an important war, are ably discussed, but cannot with advantage be summarised in the space available for the purpose in this *Journal*.

REVUE MILITAIRE SUISSE.

(1926. Nos. 1 to 6 inclusive.)—*L'organisation Général de l'Armée Moderne.* The original article, which appears in No. 2, is contributed by General Rouquerol; in it he points out that, in spite of the aims of well-intentioned people who are seeking to establish an era of perpetual peace, it still behoves nations which value their freedom and characteristic institutions to be prepared to defend them in the old-fashioned way. Armies, therefore, are still a necessity, and must be maintained in the highest state of efficiency. The requirements in connection with the recruiting of conscript armies are discussed, and the outline of an organisation for such armies suggested. The probable course of the opening phases of a war of the immediate future is sketched by the author, who points out that, although aerial warfare is likely to play an all-important part in the very early phases of a campaign, land defences have not lost their value; therefore, where permanent fortifications exist, the question of their "rejuvenation" should be considered, and, where necessary, the defence system should be remodelled to bring it up to date.

La défense anti-aerienne. In an article, in No. 2, under the foregoing title, Lieutenant E. Naef deals with the several defensive measures against aerial attack and the requirements in each case. Defence by means of air-craft counter-attacks; by means of anti-aircraft artillery; by means of *camouflage;* and by the employment of aerial entanglements, are each briefly reviewed.

L'évolution nécessaire de notre Stratégie Défensive. The problem of the defence of Switzerland, as affected by the progress in armaments and the changed conditions under which wars are waged, is discussed in No. 3 by Colonel R. de Diesbach.

Oppositions Tactiques Franco-Allemand. Captain R. Masson, in an article contributed to No. 3, examines, under the foregoing title, the contents of two recent publications—*Material oder Moral*, by General von Taysen, and *La Guerre n'est pas une Industrie*, by Colonel Alléhaut—in which the German and French views in relation to the tactical employment of troops, based on the experiences of the Great War, are set out.

Quelques Notes sur le Plan de Feux dans la Défensive. The original article appears in No. 4, and is contributed by Captain Montfort, who deals therein with the role of infantry, armed with machine-guns and automatic rifles, in a prepared defensive position.

Les Ailes de Demain. The progress in aviation made in recent times is briefly reviewed under the foregoing title by Lieutenant E. Naef, in No. 6.

W.A.J.O'M.

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CORRESPONDENCE.

OURSELVES.

DEAR SIR,

Captain Kerrich's most interesting article gives abundant food for reflection, but there is one matter which does not seem to have been sufficiently considered, and that is, What is expected of R.E. officers "from the point of view of the Army (which is the only thing that really matters)"?

The points of contact between R.E. officers carrying out their work and officers of other arms are too plentiful to enumerate, but when they turn to us in their trouble, whether it be a choked drain behind the cookhouse, failure of light in the officers' mess, lack of water in a camp, or a thousand and one things on service, it is as Engineers that they seek us, and it is by the manner in which the engineering difficulty is overcome that they will judge us. Tact is, of course, essential, but the officer with whom you are dealing will very soon spot whether you are competent to diagnose the source of trouble correctly, and, in the case of a piece of machinery, put it right with your own hands, or have to call in the assistance of your M.F.W. or a mechanic before you can make a start on the job.

In these days of mechanical and electrical appliances, I am much surprised that Captain Kerrich should suggest any reduction in the time spent on those subjects at the S.M.E. Any subaltern on active service may find himself confronted with damaged or worn-out engines, pumps, or electrical apparatus, which he has somehow or other got to make to go, and the Army at large will expect him to do it.

It was their technical qualification and experience as engineers that made our temporary officers so valuable in the Great War, and the extraordinary efficiency of the Australian Pioneers was largely due to the fact that their officers were engineers by profession before they joined up.

To revert to Captain Kerrich's article: what are likely to be the feelings of a junior R.E. officer after carefully studying it? Let us hope that he is optimistic, as he may very well be, considering the variety of the upward paths open to him, along which Providence and the A.A.G.R.E. will guide his steps. He will have his own tastes to consider, and he will probably look round to see which way the plums lie. If his ambition leads him to aspire to Westminster Abbey, or St. Paul's, or even to decorate the walls of the Chatham mess, he will quickly realise that bricks and mortar, or pumps and switch boards, are not going to help him much in that direction. Obviously he must get *p.s.c.* after his name as soon as possible. Thereafter he will aspire to command something other than the R.E. of a Division, in fact, a Brigade of Infantry, since Brigades of Cavalry and Artillery, and the Higher Commands of Tanks are "close boroughs." A staff job will come to him in due course: he should find Q work as easy as falling off a log; G work would be more to the taste of one aspiring to a command in the future, but the competition is fierce.

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The R.E. officer who deliberately goes in for a career on the Staff must recognise that he will to a certain extent lose touch with his own Corps, and he will never have that feeling towards it, and especially to our incomparable N.C.O's. and Sappers, which is only to be acquired through continuous service in R.E. units and R.E. appointments.

Further, in the matter of picking up the rewards that military service holds out to the successful, though in peace time his prospects may be good, on service he will have to rely solely on his own performances, and will not be in a position to accumulate automatically the credit achieved by the R.E. units serving in his General's command, or by other R.E. officers serving directly under him. If he fails to give satisfaction on the Staff, he can revert to Corps duty, and may arrive at the position of C.E. of a Command, but he will then be lacking in up-to-date engineer experience, and may find it difficult to conceal the fact; possibly he may fail again.

On the other hand, an Officer who sticks to the Corps, and spares no trouble to keep himself up-to-date both as regards engineering and the military art, will fill with credit to himself all the posts in the Corps that his seniority leads him up to, whilst on his way he may get the chance to switch off to a job in civil life, and find his reward in a reduced pension, but a considerable private income for life.

The great charm of continuous service in the Corps is the variety that it offers: even simple matters of building construction are differently handled in the various parts of the world in which we serve, and there is always that satisfactory feeling that all the officers and men whom you may have under your command will, under all circumstances, play up.

R. U. H. BUCKLAND,
Major-General, R. of O.

THE LATE COLONEL HENRY VERO BIGGS.

DEAR SIR,

In the obituary notice of Colonel Henry Vero Biggs, R.E., there was no mention of his greatest achievement, the achievement which perpetuates his name, *i.e.*, the invention of the "Biggs's Arm-Rack" for rifles and carbines. This pattern was approved by the Government of India to the exclusion of all other designs, and is in use from end to end of India. By means of cleverly arranged bolts, actuated by a small key in a countersunk lock, all the rifles (or carbines) are "locked" simultaneously in the stand. If any rifle is not correctly inserted in its place, the lock won't "work," and so discloses the carelessness which must be rectified. This pattern of rack has saved the theft of numberless rifles, especially on the frontiers, and Biggs got a monetary reward from the Government of India for his invention.

I would have written before, but I felt sure someone else would have drawn your attention to the omission.

Biggs was a most ingenious inventor of all sorts of appliances for shikar expeditions and building operations.

Yours sincerely,
G. P. CAMPBELL.

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An Outline of the Egyptian and Palestine Campaigns, 1914 to 1918.—By Major-General Sir M. G. E. Bowman-Manifold, K.B.E., C.B., C.M.G., D.S.O., *p.s.c.*, late R.E. Third Edition, 1926. With 17 maps and sketches. Price 4s. 6d.

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ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

Subject selected :—"Survey on Active Service."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2 :—

(a) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary ? What projection would you employ and what steps would be taken to begin Survey operations ?

(b) Do you consider the resources of the Field Survey Company adequate in personnel to undertake the programme you have outlined ? If not, what additional personnel do you consider necessary ? What reply would you make to the offer of the Colonial Survey given in paragraph 7 ? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make ?

2. The Force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of Non-Divisional and L. of C. Units. These include 1 Field Survey Company plus Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foot-hills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and are all unmetalled except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ½-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section armed with revolvers and issued with pantaloons may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the Text Book of Topographical Surveying.

3. The printing machinery includes 1 double demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

Essays must reach the office of the Secretary, Institution of R.E., not later than the 30th November, 1926. Essays must not be signed, but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with a similar pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

1. The prize, which will take the form of a piece of plate, to be chosen by the the recipient, was instituted by Mrs. Garrett in memory of her late husband, Major Arthur ffolliott Garrett, O.B.E., R.E.

2. Qualifications of the recipient : To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1926.

3. The essay must not exceed 6,000 words.

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2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

3. The name of the recipient of the Prize shall be notified in the Corps publications; and copies of the contribution for which the Prize was awarded shall be presented to the representatives of the donors.

The following are suggested as subjects for contributions:—

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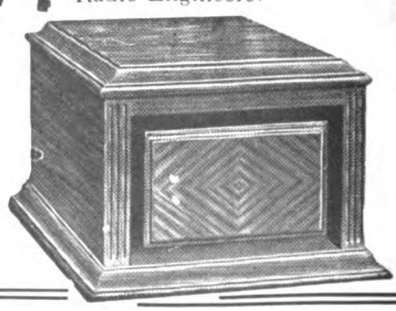

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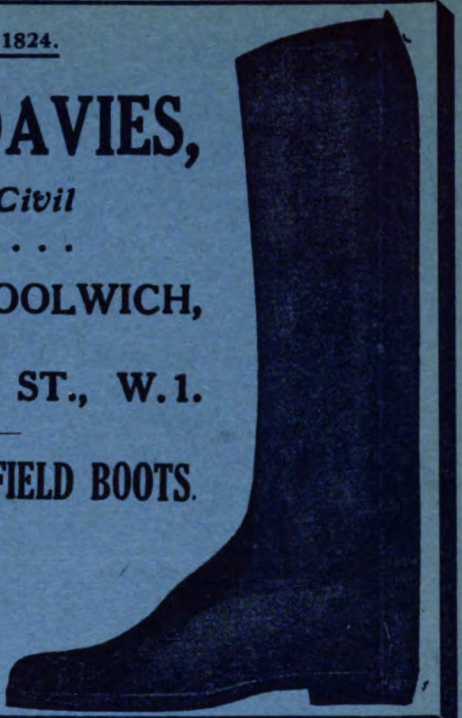

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HISTORY OF THE 20th (FIELD) COMPANY; ROYAL BOMBAY SAPPERS AND MINERS.

GREAT WAR: 1914—1918.

By MAJOR H. W. R. HAMILTON, D.S.O., M.C., R.E.

"Acti labores sunt jucundi"

PREFACE.

This history has been compiled mainly from the War Diary of the Company, supplemented by the memory of the writer. The latter has been used only to clothe the bare skeleton of the Diary, and in no case to provide the facts themselves, unless they were of very minor importance. There was, however, nothing in the War Diary from which an account of the action of Neuve Chapelle (October 28th, 1914) could be compiled. The account of this feat of arms is based on reports made by Lieutenants Nosworthy and Rait Kerr, as they then were, within three months and one month respectively of the action, supplemented by notes written recently by Major Paris. Actual times of the various events of this action are, therefore, not entirely reliable, though the general sequence of events can be taken as being reasonably accurate.

The history is not intended to be anything more than a company history, and the actions of neighbouring units and of the larger formations have only been described in such detail as is necessary to make the account clearer. Only in one case does this strictly limited view lead to difficulties; that is in the account of Neuve Chapelle. In that instance, in order to provide a clear picture of what occurred, the actions of the 9th Bhopals, the 47th Sikhs, and of the 21st (Fd.) Company, 3rd Sappers and Miners, should have been included. These actions, though not mutually co-ordinated, were all part of one connected whole. On the other hand, the writer has had such difficulty in constructing any connected account of the action of the 20th (Fd.) Company alone, that he has despaired of ever being able to include the deeds of these other units within the scale of the picture provided by the material at his disposal.

It has been intended throughout to emphasise the part played by the men of the Company during the war, to record their gallantry and their determination, the dangers which they faced and the hardships which they endured, their never-flagging energy and their

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abiding loyalty to their King-Emperor and to their officers. The work of the British officers has been left largely to speak for itself. But it should be recorded that of the thirty-three British officers who served with the Company up to the time of the Armistice, sixteen were temporary officers, either R.E. or I.A.R.O. Without the skill and technical knowledge which these latter officers brought to their work, without the ready way in which they immediately made themselves part of the Company, without their energy, loyalty and pluck, the work of the Company would not have been what it was.

It is not expected, nor is it the writer's intention, to add anything to the already voluminous history of the Great War. The main object has been to supplement, as far as possible, the briefer official history of the Royal Bombay Sappers and Miners. It is hoped that some at least of the incidents herein recorded may assist officers responsible for the teaching of Corps history, and also that this history may prove of interest to those who served with the Company during the Great War.

PART I. FRANCE.

August 1914: Mobilization.

On the 10th August, 1914, the Company, at that time the 20th (Fd.) Company, Third Sappers and Miners, received orders to mobilize, and left Kirkee on the 16th August, under the command of Captain A. L. Paris, R.E. The following British and Indian officers and British N.C.O's. accompanied it:—Lieutenants F. P. Nosworthy, R.E.; E. J. B. Hayes-Sadler, R.E.; R. S. Rait Kerr, R.E.; Subadar Ganpat Mahadeo; Jemadars Shah Wali Khan and Baryam Singh; Corporals M. A. Sprinks and C. Harris, R.E. It may be added that Subadar Arjan Powar, who had been senior Indian officer of the Company since 1906, had been promoted Subadar Major of the Corps only a few days earlier, and would otherwise have proceeded on service with the Company. This fine Indian Officer was in no small degree responsible for the splendid spirit which the Company showed in its very first action in France.

S. S. Taiyibeh.

The 20th and 21st (Fd.) Companies embarked at Bombay in the S.S. Taiyibeh on the 17th August, and sailed on the 24th. This ship had been previously condemned as unfit to take pilgrims from Bombay to Jedda, and was manned by a scratch crew hastily collected by the Naval authorities. It soon appeared that the

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condemnation was based on reasonable grounds. The ship was in a thoroughly insanitary condition; and as soon as she left harbour, and met the monsoon, it was found that the lower deck ports could not be closed, except by using canvas caulking on the dead lights. Before this could be done, however, the troop decks were flooded, and while this makeshift kept out water to a certain extent, it had the effect of making the ship very dark; and in spite of all efforts there were never less than six inches of water in the officers' cabins. To crown all, the engines broke down. The Commander later told Lieutenant Nosworthy, that, if he had not had Sappers on board, he would have been very doubtful of making port. This shows a somewhat touching confidence in the capabilities of the Corps.

Egypt.

Eventually the ship reached Suez, where the Company disembarked. The Company then proceeded by rail to Cairo, where the whole of the 3rd (Lahore) Division was concentrated to take the place of the British Garrison, which had gone to France. Five days were spent here under canvas at Heliopolis, on one of which the Division carried out a long and tiring demonstration march through the streets of Cairo.

Having re-embarked at Alexandria the Company finally disembarked at Marseilles on the 26th September, and went into camp on the Parc Borely racecourse. Entraining again on the 28th September, it reached Orleans on the 1st October. It is believed that the Company was the first Indian unit to pass through France.

The whole of the 3rd (Lahore) Division, less the Sirhind Brigade, which had been left in Egypt, was now concentrated at Orleans, and partly re-equipped for European warfare. Though all were eager to commence active operations, little was known of the type of warfare into which Indian troops were now about to be plunged. While the standard of training of our troops was rightly valued, the strength of the Germans was by many sadly underestimated.

The Company Proceeds to the Front. *Map* 1.

The Company entrained at Orleans on the 17th October, detrained at Wizernes on the 18th, and billeted at Esquerdes until the 21st. Marching thence with the 3rd (Lahore) Division through Bailleul and Estaires, it reached La Gorgue on the 23rd, and went into billets.

General Situation.—The scope of this history is limited, but it may be here mentioned that at this time the B.E.F. was holding the general line Givenchy—Armentières—Ypres, and repulsing the attacks of superior numbers of German troops, many of them fresh formations. The Indian Corps, composed of the 3rd (Lahore)

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and 7th (Meerut) Divisions, less the 7th (Ferozepore) Brigade, which had been lent to the British Cavalry Corps, and the 9th (Sirhind) Brigade, which was still in Egypt, came up behind the British 2nd Corps, on the general line Festubert-Neuve Chapelle, and gradually relieved it. The Lahore Division, which had, as will have been noticed, only one Brigade at its disposal, was more immediately concerned with the neighbourhood of Neuve Chapelle and the Rue du Bois ; but the troops of this Brigade were to a great extent sent into action as individual units, wherever reinforcements were required, and often under the command of British formations.

Meanwhile the 20th Company was employed from October the 24th to the 27th digging second-line positions near Fauqissart, Le Touret and Lacouture. Company billets were at Le Touret.

NEUVE CHAPELLE : *October 28th. Maps 1 and 2.*

During the morning of the 27th, the Company billets were moved to Bout de Ville. At about 4 p.m. on that day, just after the Company had finished work south-east of Lacouture, orders were received for the whole Company to concentrate at Richebourg St. Vaast. Captain Paris thereupon ordered up the company transport and all available men under Lieutenant Rait Kerr. These arrived at 6.0 p.m. As the situation was uncertain, and conditions were those of open warfare, a standing patrol of No. 4 Section under Lieutenant Rait Kerr was placed at the cross roads of Richebourg L'Avoué, and remained in position until relieved by a cavalry patrol at 7.30 p.m. At about 8.15 p.m. the situation was explained to Captain Paris. This was, in general terms, that the troops of a British Brigade had been forced to retire from Neuve Chapelle, and a re-entrant had thus been driven into the British line. The Company was ordered to dig itself in on the left of the 9th Bhopals, who were in the vicinity of Port Arthur (at the junction of the Rue du Bois and the La Bassée road), while the 21st (Fd.) Company, 3rd Sappers and Miners, which was also being ordered up, were to prolong the line to the left. Both Companies were placed under the orders of the commander of a British Infantry Brigade. These dispositions would have the effect of forming a new battle front west of, and excluding, the village of Neuve Chapelle. The Company was ordered to proceed to Pont Logy, where a Staff Officer was to be met who would direct the Company to the proper position.

On arrival at Pont Logy this Staff Officer was found, but he could do no more than recapitulate the orders previously received. The Company had, therefore, to locate the left flank of the 9th Bhopals without assistance. The night was dark and the position was hard to find. First a British Battalion, with officers reduced to two 2nd Lieutenants, was located, and then the right flank of the 9th Bhopals. The movement of the Company along the line of the latter unit

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was not facilitated by the sudden bursts of fire, which are not uncommon in difficult and uncertain situations. It was not until 11.0 or 11.30 p.m. that a position was reached, beyond the left flank of the Bhopals, where the Company dug in.

An officers' patrol was sent to look for the 21st (Fd.) Company, The latter had had a similar experience of wandering in the dark. and was finally found entrenching away to the left, with an unoccupied gap of some 600 yards between the Companies. The British Brigade, under whose orders the two Companies were acting, was informed of this, and the gap was filled just at dawn by two Companies of the 47th Sikhs. During the night two casualties occurred, the first in the Company.

Dawn broke at 5.30 a.m.* and found the Company still digging. The trenches, though incomplete, afforded cover, and were occupied, officers and men lying down to a well-earned rest.

Orders to Attack.—At about 5.0 a.m. Captain Paris had been called back to Pont Logy for orders. These were that an artillery bombardment of the village would start at 7.0 a.m., would continue for half-an-hour and would be followed by a general attack. These orders were subsequently cancelled, and the attack was postponed until 11.15 a.m., but the bombardment took place at the earlier hour, causing considerable damage to the village and bringing down the church steeple. It is presumed that this postponement was ordered so as to obtain the co-operation of the 4th D.G's., who were not expected before 11.0 a.m. Actually the latter had not arrived at 3.30 p.m., and were unable to assist.

The following is a copy of the written orders for the attack :—

"An attack against Neuve Chapelle road from about the L of Les Brulets to the road junction La Bassée—Neuve Chapelle road, with the object of regaining trenches previously held by 9th Brigade Infantry, is to be made to-day. It will commence with the bombardment of our guns, assisted by a French Battery.

On the attack being ordered the movement will be from the right in a south-easterly direction. Troops should not move further forward than the trenches originally occupied by the 9th Brigade, except on the left of the line, where the advance should be made sufficiently far to allow of the houses south-east of the road triangle north-east of second E of Neuve Chapelle being burnt.

The 2nd Cavalry Brigade will support the right of the attack with their left directed on Neuve Chapelle church. The North Staffords and Royal Scots and the French chasseurs and cyclists at Rouge Croix under General Shaw will have orders to support the left of the attack with their right on Neuve Chapelle church. Com-

* Lieutenant Rait Kerr's account. Sunrise is at 6-45 a.m.

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munication centres have been established at the road junction south of first E of Chapelle and at the farm just north of the O in Logy.

At 11 a.m. a general bombardment of the position to be attacked will be commenced, and at 11.15 a.m. without further orders a general advance will be commenced, units taking care to connect up on their right and left.

From 7th Infantry Brigade.
RICHEBOURG ST. VAAST. 10 a.m."

At 11.0 a.m. on the 28th, a second and heavier bombardment began, 18 prs., French 75's., 4.7's and 60 prs. all taking part. This bombardment lasted half-an-hour. When it ceased, our troops were seen to be attacking in succession from the left, and Captain Paris decided to co-operate. He ordered the Company to attack in echelon of sections from the left, and informed the nearest company of the 9th Bhopals.

Description of the Village. Neuve Chapelle was at that time a small, pretty, somewhat straggling village, with a conspicuous Church, forming the junction of several radiating roads. Timber and orchards concealed it to a certain extent from our lines, but on the east of the village the ground was more open and extended for 500 to 600 yards up to the Bois de Biez. The Germans were thus able to fire down the roads leading into the centre of the village, the village itself being masked from our lines, except for the fact that from Port Arthur a limited view could be obtained of its western outskirts.

The Attack. Three hundred yards of plough separated the Sappers from their objective. This distance was covered with little loss; but the 9th Bhopals, who at first advanced in touch, were unable to make further progress, and the 20th Company came under heavy fire from the right flank. Lieutenant Nosworthy and No. 3 Section, however, changed direction and succeeded in charging a trench at A., which was causing some of the trouble, with the bayonet. Meanwhile the 9th Bhopals, though this was not known at the time, were heavily engaged further to the right, and except for a small party under Major Jamieson, were not able henceforward to spare any men to take part in the actual fighting in the village itself.

The four sections of the Company succeeded in penetrating the village, and reached the main street, where they suffered losses from the fire of Germans occupying the houses, and of machine-guns, east of the village, raking the streets. Some confusion ensued, but eventually, after hand-to-hand fighting in houses and cellars, the whole street was captured as far as the eastern outskirts of the village. Lieutenant Hayes-Sadler then headed a party in a gallant effort to charge one of the enemy machine-guns, but he was killed and the attempt failed.

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Captain Paris wounded. Meanwhile, Captain Paris, seeing that the right flank was exposed, and that the Bhopals were not advancing, went back and collected a few of them under a havildar from the nearest trench, where at the moment none of their officers could be seen, and moved with them and one or two stragglers of the Company towards the southern houses of the village. The party suffered some loss, and just before reaching the houses, Captain Paris fell severely wounded. He was eventually picked up by the enemy after dark, and remained a prisoner until the end of the war. As the Company did not know where he was, and did not retire over the ground where he lay, they were in no way to blame for not picking him up. Captain Paris had commanded the Company for over seven years, and it was a hard blow that he should have been lost in this its first, though its most glorious, action.

The Company was now scattered on a wide front, and only about 20 men remained with Lieutenants Nosworthy and Rait Kerr in the centre of the village; while other parties had attached themselves to the 47th Sikhs on the left. At about the time that Captain Paris was endeavouring to obtain reinforcements, as has been stated above, Lieutenant Rait Kerr was sent back by Lieutenant Nosworthy to obtain help. He returned to the south-western edge of the village, where he found Major Jamieson, with about six men, firing on a strong German counter-attack, which was working round our right. Collecting three or four Sappers he went to their assistance, but on the way he was hit in the arm, fell into a ditch, and fainted. Here he lay for some considerable time.

Lieutenant Nosworthy was thus left alone in the village, except for the 47th Sikhs further to the left. Two further messages for help produced no result. His party had by this time barricaded the main street, which was continuously enfiladed by German machine-guns, and felt themselves reasonably secure. He later gave it as his opinion that, had help been forthcoming, he would have been able to hold on to the village, as his men were now ensconced in houses from whence they could reply to the enemy's fire.

The Withdrawal. At about 3.30 p.m., Major Jamieson of the 9th Bhopals, and a few of his men, entered the village by the road which the Sappers were holding. One more attempt was made to charge a machine-gun, but only failure resulted; and, as Major Jamieson said that the attacks on both flanks had failed completely, it was determined to fall back.

Lieutenant Nosworthy and thirteen others, including Subadar Ganpat Mahadeo retired out of the village, and though fired on in doing so suffered no further loss. Lieutenant Rait Kerr was met on the way. The latter, having recovered consciousness, had picked up a naik in the 9th Bhopals and Sapper Dalip Singh of the

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20th Company, and, seeing that the Germans appeared to be attacking on the north of the village, had proceeded with these two men in that direction. All three took cover in a shell-hole, covered by some peastakes, at a point west of the church and not far outside the village. Lieutenant Rait Kerr then ordered the two men to open rapid fire on the enemy who could be seen on the edge of an orchard. This had the effect of causing the Germans to withdraw. Lieutenant Rait Kerr then seeing that our troops were retiring returned to the trench from which the attack had started that morning, and met Lieutenant Nosworthy as stated above.

Having collected as much equipment as could be carried, the whole party moved to near Pont Logy, where an officer of the 4th D.G's asked for help in holding the houses at that point. This was given, but orders were soon received to proceed to Rouge Croix, and thence to Estaires, where Lieutenant Nosworthy reported to the C.R.E. at 8.0 p.m. The remainder of the survivors of the Company drifted back and rejoined that evening and during the course of the next day.

Losses.

The following is a list of casualties :—

Killed	Lieutenant Hayes-Sadler and 21 Indian other ranks.
Wounded and Prisoner ..	Captain Paris.
Wounded	Lieutenants Nosworthy and Rait Kerr Jemadar Baryam Singh and 3 Indian other ranks.

Thus the casualties in British Officers were 100%, and in Indian ranks 30% of the total strength of the unit, including drivers and others who were not closely engaged or who did not go into action.

Acts of Gallantry. Many acts of gallantry were performed by men of the Company in this affair, which, owing to casualties among British officers, were never recorded. It must be remembered that the Company was acting on a very extended front, and that other parties, besides that with Lieutenant Nosworthy, fought in the village and maintained themselves there the whole afternoon. Those who fought alongside the 47th Sikhs covered themselves with glory. The strong bond of comradeship between the 3rd Sappers and Miners and that fine corps, which dates from the day of this action, bears witness to the deeds done that day in company.

Three decorations were awarded to men of the Company for work done this day. Havildar Muhammad Khan, who was mortally wounded, and Sapper Dalip Singh both received the Indian Order of Merit, for conspicuous gallantry. Naik Shah Nawaz also was noticed for conspicuous gallantry in street-fighting by Major Davidson of the 47th Sikhs, who, however, was unaware of his name. This Naik was wounded later in the action, and did not receive his

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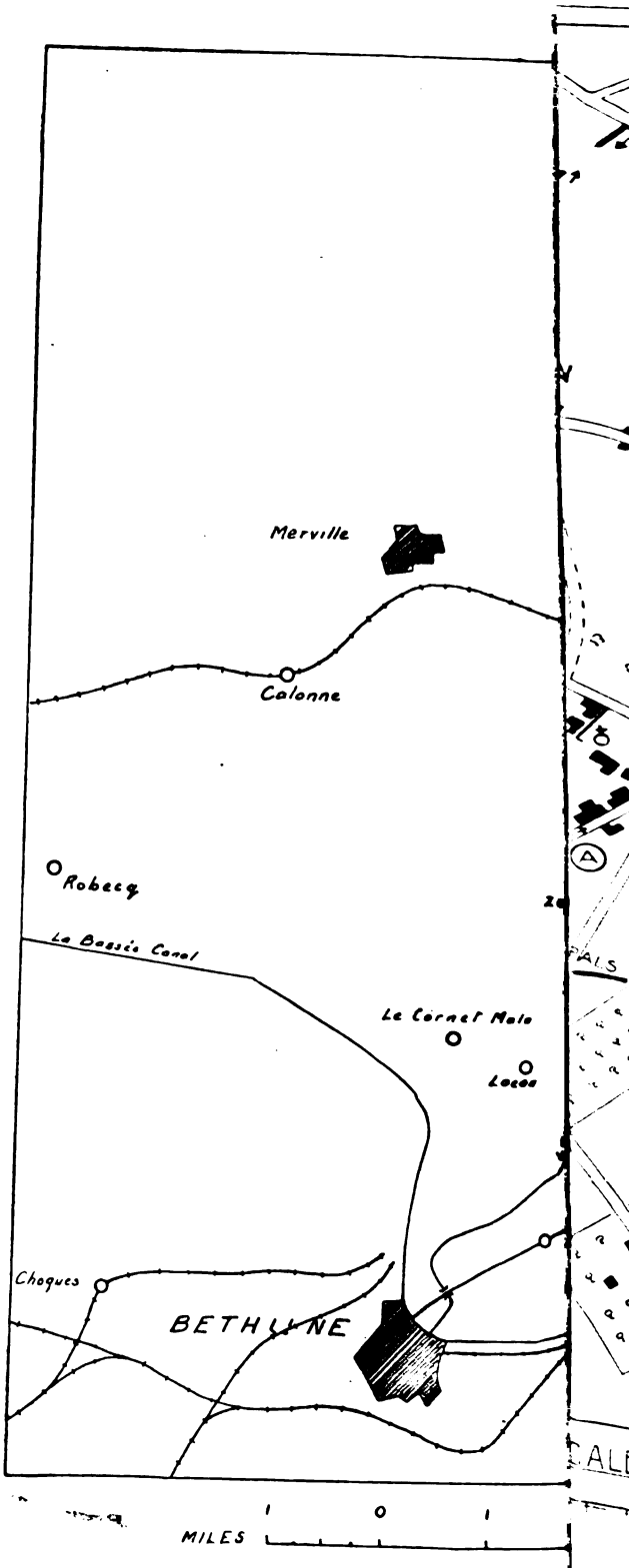

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reward until five years later, when, having been transferred as an Indian Officer to a Pioneer Battalion, he was on parade for inspection by General (late Major) Davidson. The latter recognised him, and asked where they could have met before. On hearing that it was at Neuve Chapelle, the General remembered the circumstances, and immediately recommended him for the I.O.M., which was granted.

These three decorations were the only ones given to the unit for the action, but the work of the 20th and 21st (Fd.) Companies was noted by General Sir John French in his despatch of the 20th November, 1914, which reads :—

" On the 28th October, especially, the 47th Sikhs and the 20th " and 21st Companies of the 3rd Sappers and Miners distinguished " themselves by their gallant conduct in the attack on Neuve " Chapelle, losing heavily in officers and men."

The following is an extract from the history of the 59th (Fd.) Company Royal Engineers which appeared in " The Sapper " of July, 1921, referring to this action :—

" A Staff Officer of the 3rd Division told me that it was one " of the most gallant feats he had ever seen, and regretted that " the circumstances should have been such as to necessitate the " use of engineers on such a service."

The Company now went into billets at Sailly, and Captain Stack, R.E., field engineer to the Lahore Division, took over temporary command.

November 1914. Trench Warfare. *Map* 1.

On the 1st November, Captain Birney, R.E. and Lieutenant Robson joined the Company, the former assuming command, and on the 2nd November Lieutenant Hamilton, R.E., also joined.

During the ensuing fortnight work was carried out sometimes by day and sometimes by night on the front and second line trenches in the Rue Tilleloy area. Second line trenches which were 600 to 800 yards behind the firing line were usually dug by day, though they were under observation from Aubers ridge. The importance of concealment was not sufficiently appreciated at that time, and the Company used to march on to work taking little care to remain concealed. The Germans occasionally shelled the working parties with shrapnel without effect, but on the night of the 4th-5th they dropped a bouquet of howitzer shell right in the working party, killing 3 men and wounding Jemadar Shah Wali Khan and 2 others. Subadar Ganpat Mahadeo was now the only survivor with the unit of the seven officers, British and Indian, who had left Kirkee with the Company.

On the 14th, the Company moved into billets two miles north-west of Estaires, but it was turned out again at 7.30 p.m. and

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marched 6½ miles to the trenches to dig a new length of fire-trench connecting the lines held by the 47th and 15th Sikhs. Much time was wasted in the dark finding officers who knew the location of the work; but, after stumbling through interminable trenches over prostrate forms,* both British and Indian, the Company eventually started operations in a field of roots, and quickly finished a passable trench. The men were not back in billets until 7.45 a.m. on the 15th.

On the 16th, the Company moved into fresh billets near Lacouture and rested that day and the next. On the 17th, it was reinforced by a pontoon section consisting of 10 British drivers R.E., 19 horses and 3 wagons, which remained with the unit until it landed in Mesopotamia. The N.C.O. in charge, Corporal Clark, R.E., however, was with the Company until he was demobilized in 1919.

On the 17th, the following Officers arrived and took over duties :—

Major A. R. Winsloe, D.S.O., R.E.,
Captain W. P. Pakenham-Walsh, R.E.,
Lieutenant H. G. Greswell, R.E.,
Lieutenant M. Everett, R.E.

Captain Birney was ordered to railways, Lieutenant Robson to the 1st (K.G.O.) Sappers and Miners, with the Meerut Division, and Lieutenant Hamilton to military works on the L. of C. The latter, however, delayed his departure, and a few days later was re-posted vice Lieutenant Everett, who had injured himself riding.

FESTUBERT. *Map* 3.

Manufacture of Bombs. On the 18th, the Company moved to Gorre, a somewhat squalid village some two miles behind the Givenchy-Festubert Sector, which was held by the Meerut Division. Here a factory for hand-grenades (jam-tin bombs), trench mortar ammunition, and charcoal braziers, was started; and the work on these articles was continued at high pressure and without intermission until the 24th. The grenades and mortar bombs were somewhat crude affairs, and the latter were extremely apt to explode at the muzzle of the mortar, which was either a wrought-iron tube or a hollow wire-bound piece of timber. Classes of Infantry were instructed in the art of throwing the hand-grenades, but pupils generally were not enthusiastic!

On the 23rd November, the Germans attacked and captured the trenches held by the 34th Sikh Pioneers in front of Festubert. Heavy losses were inflicted on counter-attacks across the open; and the situation was critical until Lieutenant Robson, now with the 1st (K.G.O.) Sappers and Miners, took a leading part in a bombing

* It says much for the spirit of the British Soldier that not once did a sleeper utter any of the expletives peculiar to his calling. "Hullo Johnny!" and "*Thik* Johnny!" were the only words that were heard."

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attack from the flank. The Germans were driven out and some 100 prisoners taken.* It was thought at the time that this was the first instance of the tactical use of bombs during the war, but a British Division claims to have earlier originated the idea of bombing from traverse to traverse. After this, hand-grenades became more popular with the infantry.

It was about this time that the Indian Corps copied the "Hair-Brush" bomb from the Germans, and that Captain Battye, R.E., commanding the 21st (Fd.) Company, 3rd Sappers and Miners, started the manufacture of Battye bombs in Béthune.

On the evening of the 24th, the Company, less 2 Sections, was ordered at short notice to clear ammunition urgently required in the trenches from a shell-wrecked house in Festubert. The work was hindered by shell-fire, three men being wounded, and Captain Pakenham-Walsh, in spite of his girth, propelled some distance by a bursting shell. Ammunition had, however, been brought up from Gorre, and 13 boxes were carried up to the front line by the Sappers.

On the 24th November, work in the trenches of the Festubert sector was taken over from the 1st (K.G.O.) Sappers and Miners. The situation here was somewhat difficult, as the Germans had sapped up to within 5 or 10 yards of our trenches in five or six places, and had completed a parallel about 50 yards away along the whole front. In two places their saps had broken into our trenches during the fighting of the 23rd. The enemy had distinctly the upper hand in bombing; and their trenches were far better drained and constructed than ours. They had good loop-holes from which they harassed our observation posts and communication trenches; and a few snipers had managed even to get through our lines on the 23rd, and maintained themselves in hay-stacks and houses behind our lines, whence they fired at single men at night, and they were very hard to locate. One of these enterprising individuals was thought to use a .22 rifle by day with disconcerting effect.

The general line of trenches can be followed in Map 3. It should be noted that on the 24th November our line had no depth. Support, communication and reserve trenches hardly existed, and there were no dug-outs worthy of the name. The firing-line was cut off from the rear by day and men slept in the open at night, crowded in the front line trenches, with waterproof-sheets as their only shelter from the frequent rain.

From the 24th November until the 3rd December, the Company, reduced in strength as it was, worked hard to improve the position,

* For a good account of this action read the "History of the 39th Royal Garhwal Rifles." Although the 20th Company took no part, this action has been mentioned in some detail, as Lieutenant Robson was a Sapper Officer and had served in the Company.

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digging communication and support trenches, and endeavouring to devise means to strengthen those portions of our position threatened by the German saps. The only measures which could have been any use would have been counter-sapping, for which our Sappers were all too few, and bomb-throwing, for which our bombs were still insufficient. The use of bombs was still not very popular with the infantry. A few bolder spirits, like de Pass of the Cavalry,* obtained a temporary superiority over the Germans in bombing, and where they did so, the situation was greatly eased. One of the Sapper Officer's duties throughout this period, therefore, was, if he had the time, to give practical exhibitions of bombing into the German sap-heads, and there is no doubt that a few good shots by Lieutenant Robson or Greswell did much to encourage the embryo British grenadier.

The Piquet House. One of the most useful pieces of work was carried out by Captain Pakenham-Walsh and detachments of the 20th Company in the Piquet House near Hell Corner (vide Map 3). This building was within 10 or 15 yards of the enemy's advanced parallel, and was subjected to continual bombing. It was important to hold it, as it flanked a large part of our line and overlooked the enemy trenches. Working by night, frequently under bomb and rifle fire, the Sappers improved the defences of this building; when the work was finished, this house thus fortified formed a very useful "point d'appui" in our line.

In addition bomb-making was continued during the day-time. On the 24th, for instance, as many as 450 jam-tin bombs were made.

On the 28th November, Lieutenant Greswell was wounded while returning from the trenches, and evacuated next day.

December, 1914.

Rest. On the 3rd December, work in the trenches was handed over to No. 3 Company, 1st (K.G.O.) Sappers and Miners, and the Company had a period of rest, but was still employed in turning out bombs, loop-hole boxes, and other trench stores. Infantry squads were exercised almost daily in bombing, and some pontoon drill was carried out.

On 3rd December, Lieutenant Johnstone, R.E. joined the Company.

Festubert Again.

On December 12th, the Company again took over the Festubert sector, and work was continued as before. Our bombers, however, were by this time dominating the German sap-heads; and the enemy, finding further progress therein impossible, were now engaged in driving a series of Russian saps, or shallow mines, towards our trenches. Although the Infantry reported suspicious noises,

* Awarded a posthumous V.C.

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listeners specially sent to the trenches heard nothing, and the report was unfortunately not credited.

On the 13th, Captain A. R. C. Sanders, R.E., took over command from Major Winsloe, but on the 15th he was slightly wounded by a bomb, while accompanying a reconnaissance attack on a German sap. Two Sappers were also wounded on this occasion. Captain Pakenham-Walsh took over command, and handed over again to Major Winsloe on the 17th.

On the 16th, troops on the right were conducting a minor operation, and the Company moved up to a position of readiness; but no further move was ordered, and the men were back in billets at 1.0 p.m., where they immediately set to work and made 150 hair-brush bombs, which were urgently required.

Action on the 19th. On the 18th and 19th, our counter-saps were driven forward without intermission. On the latter day an abortive attack was made by the Indian Corps on the Givenchy front. A section of the 20th Company was detailed to accompany an isolated attack by a company of Gurkhas on the Festubert front at dawn on the 19th, but the Gurkhas were not ready to attack at zero hour. However, the company commander of the Gurkhas considered that his orders were to attack as soon as he was ready, and he asked Lieutenant Hamilton to join up our sap with the German sap as soon as the attackers had taken the German trenches. No covering fire of any sort was arranged, with the result that the Gurkhas were mown down by the fire of many machine-guns before they had gone a few yards. Two very gallant British officers were lost in this mistaken endeavour, together with many men. The Sappers then naturally found it impossible to work in the open at joining up the saps, but work was continued below ground.

German attack on the 20th. At an early hour on the 20th, the Germans exploded a number of small mines under our trenches, attacked on the whole front from Givenchy to the left of the Piquet House, and succeeded in capturing our front and support lines after confused fighting.

Lieutenant Hamilton, who was billeted in Festubert with a section, was ordered by the Brigade Commander of the Sirhind Brigade to take up a position in reserve just in rear of the village. The Germans however, did not make any further attack on our very weak line, and later in the day the section was ordered back to Gorre.

The Manchesters later succeeded in driving the enemy out of Givenchy, and, the 1st Division having arrived, the line was stabilized after a series of costly counter-attacks.

Some Remarks. The failure of the Indian Corps to retain the line which it held for two months was due to the following causes :—

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(1) The small number of technical troops available. The Lahore Divison had only two Field Companies, both more than 30% under strength; and the pioneer battalion, having been used as Infantry, had been very much weakened during the fighting of the 23rd November.

(2) The general ignorance of trench warfare and bombing.

(3) The packing of the front line with troops.

(4) The complete lack of engineer stores. The rise of the sub-soil water in the low ground in front of Festubert, converted the trenches into quagmires, and caused great suffering to the troops. Timber for dug-outs, trench-boards and revetments was unobtainable.

(5) The failure to realize the key position of Givenchy. The latter might have been made impregnable and the low, swampy ground in front of Festubert lightly held. Trenches along the general line of Festubert village and its road would have been comparatively dry and concealed from observation.

In this connection it should be noted that Captain Sanders, R.E., had personally sited two machine-gun positions on the northern slope of the Givenchy spur, which raked the line of our trenches, but these posts were unfortunately observed by the Germans, and put out of action by shell-fire before the attack.

On the 21st and 22nd, the Company remained in a state of readiness at Gorre. On the latter day the billets were shelled, and, as nearly a ton of guncotton was stored in them, a move was necessary.

Driver Tanner, R.E., was badly crushed between two heavy draft horses while removing them to safety under shell-fire. He later received the D.C.M.

THE COMPANY MOVES TO MARLES.

On the 23rd, the Company moved to rest billets with the Ferozepore Brigade in Marles-Les-Mines, and on the 24th, Captain Pakenham-Walsh took over command from Major Winsloe.

Thus ended the Company's share in the operations of 1914, which have been described in some detail, owing to their novelty and, it is hoped, their interest.

It was in these operations, at any rate, that the Third Sappers gained their reputation for hard work and gallantry, a reputation which they have never lost. Under a continual succession of new officers, the men carried out their duties, whether in the line or nominally at rest, to the satisfaction of their superiors, and to the admiration of many who had never seen them at work before and were ignorant of their esprit-de-corps, and splendid traditions.

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REST: CHRISTMAS, 1914.

The period from the 24th December to the 14th January, 1915, was one of rest and refitting, varied by such Christmas and New Year celebrations as could be arranged. On Christmas night the British drivers of the Pontoon Section gave an excellent "sing-song," which was attended in full strength by all Indian ranks, and apparently vastly appreciated. Much time was spent in teaching the Infantry the elements of trench design, as it was realised that the Sappers could not be expected to do everything for them. This instruction undoubtedly bore good fruit.

On the 26th December, a draft of one Indian Officer (Jemadar Ali Bahadur) and 39 Indian other ranks joined the Company.

On the 31st December, the Company paraded for inspection by the G.O.C. Indian Army Corps, Lieutenant-General Sir James Willcocks, who delivered a complimentary speech. The fluent Urdu of the General, though completely above the heads of most of those present, immensely gratified the men.

JANUARY, 1915.

Trench-work, Rue Du Bois. Map 1. On the 4th January, Captain Sanders rejoined and took over command.

On the 15th January, the Company moved by 'bus to Zelobes, and marched thence to Richebourg Saint Vaast, where it remained until the 22nd improving the defences of the Rue du Bois. The front here was quiet, as both sides were engaged in combating the Flanders mud, and were too busy to engage in any offensive operation. Our front line east of the Rue du Bois was discontinuous and lightly held. The houses of this straggling village, which formed the main-line of defence, were still comparatively intact, and full of the property abandoned by the French owners. It was an amusing sight to see the Gurkhas, sitting on the door-steps, wearing seedy bowler-hats, and admiring themselves in cracked hand-mirrors. The weather was cold and wet and on the 18th there was a heavy fall of snow. Captain Nosworthy rejoined here, to the great satisfaction of all ranks.

Rest at Marles. On the 22nd, the Company marched to Chocques, and thence on the 23rd, to its former billets at Marles, where it lay at rest until the 1st February, when it marched with the Sirhind Brigade to billets near Calonne. It remained at Calonne until the 11th February, drilling, practising Field Works, experimenting with catapults and rifle-grenades, and pontooning.

FEBRUARY, 1915.

Trench work, Le Touret. Map 1. On the 11th February, it marched to Le Touret and took over a sector of the position from No. 4 Company 1st (K.G.O.) Sappers and Miners. This sector lay to the north of our old Festubert position and was badly waterlogged.

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Much work was done in making breast-works and in putting out wire. The former consisted of a parapet revetted by plank hurdles, which were turned out in large quantities in the Company workshops; the latter was usually composed of "knife-rests," which were sometimes of colossal size. These were carried down to the trenches and wired "in situ." On one occasion a regrettable incident was nearly caused by a carrying party of the 34th Sikh Pioneers, which missed our trenches and proceeded unconcernedly towards the German line, pursued with strange oaths by two R.E. Officers.

Rest at Robecq. On the 23rd February, the Company marched back to rest billets at Robecq, where it remained until the 4th March. The Brigade Commander of the Sirhind Brigade informed the O.C. Company, during this period, that the work of the Company had been brought to the notice of the Divisional Commander.

March, 1915.

Preparation for the Attack on Neuve Chapelle. Maps 1 and 2. On the 4th March, the unit proceeded to Le Vert Lannoy in order to assist the Sappers of the Meerut Division to construct bridges over the Lawe Canal, which were required in the forthcoming attack on Neuve Chapelle. Several bridges were constructed here, and other preparations and reconnaissances carried out. Captain Nosworthy, with his personal knowledge of the ground, was now greatly utilized by the staffs of higher formations, to whom he paid continual secret visits!

As is well-known, the First Army was about to attack the German line west of Neuve Chapelle and the Aubers ridge. A big advance was confidently expected. Maps and information of the country as far east as Lille were issued to the lowest formations, and a First Army Order of the Day, dated the 9th March, stated that 48 battalions were about to attack a locality held by 3 German battalions, and that at no time during the war had circumstances been so favourable to our arms. This estimate of the strength of the German troops did not, of course, include their reserves.

Neuve Chapelle. On the 10th, after a heavy bombardment, the attack was launched. The Meerut Division broke through the defences of Neuve Chapelle and the 4th Corps had a similar success on their left. Parties of the Meerut Division even penetrated the Bois de Biez, but were unable to maintain the ground won. The Lahore Division remained in reserve.

Meanwhile, the 20th Company, having moved on the 9th to billets between Fosse and Le Marais, marched on the 10th into close billets between Vieille Chapelle and Zelobe, leaving the 2nd line transport at Fosse.

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On the 11th, the Meerut Division and the 4th Corps endeavoured to press forward, but the attempt failed. During the morning the Company moved to Richebourg Saint-Vaast, and the same evening proceeded with the Sirhind Brigade, taking the 1st line engineer equipment, into Neuve Chapelle, where it occupied a small ruined farm. The column came under shrapnel fire on the La Bassée road, and the Company lost three Sappers and one Sapper-driver wounded.

At dawn on the 12th, the enemy opened a heavy bombardment, followed by a strong counter-attack from the Bois de Biez. This attack was beaten back with severe loss. The Company was employed during this attack in carrying ammunition to the front line, and no consolidation work was done. The Sirhind and Jullundur Brigades then received orders to attack the Bois de Biez, but, as the 4th Corps had failed to advance on the left, this attack was countermanded, and the consolidation of our line east of Neuve Chapelle was commenced.

During the course of the day the following casualties occurred :—

4 Indian other ranks killed,

Lieutenant Hamilton, Sergeant Harris and 20 Indian other ranks wounded.

Consolidation.—A period of hard work now followed while the Sappers and Miners were engaged in improving the defences of Neuve Chapelle, in wiring, and in constructing shelters and command posts. On the 13th, one I.O.R. was killed and 10 wounded, but after this the Germans became quiescent, and no further casualties occurred. On the 14th, the Company occupied billets at Windy Corner in order to be nearer the work.

On the 15th, 2 Indian officers and 32 Indian other ranks of the Malerkotla Imperial Service Sappers and Miners arrived, and henceforward formed a fifth section, and, on the 20th, Captain M. Rawlence, R.E., joined the Company.

Much useful work was accomplished by officers of the Company, who reconnoitred the ground in front of our position almost every night; and Captain Nosworthy later received the M.C. for the good work which he carried out during this period. It is difficult, without going into too great detail, to give an idea of the hard work necessary night after night during these days. Suffice it to say that the Company was honoured by several letters of thanks, of which the following are examples :—

Extract from a letter addressed to the Officer Commanding Sirhind Brigade :—" The G.O.C. wishes me to convey to you his appreciation of the good work done by all ranks of the party which reconnoitred the German trench near point B last night and demolished it."

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Extract from a letter from the G.O.C. Lahore Division to Major Sanders, R.E., commanding the Company—"I would, therefore, ask you in the meantime to assure all ranks how much the splendid qualities shown by all have done to uphold the highest traditions of our Army, as well as to gain a very brilliant and appreciable victory for the Allied Arms."

The G.O.C. Indian Army Corps also addressed a letter of thanks to his Chief Engineer for the excellent services of the Sappers and Miners and Pioneers,—". . . since the Army Corps arrived in France, and prior to, during, and since the fighting round Neuve Chapelle."

A curious incident which occurred during this period of consolidation may be mentioned here.

One night Major Sanders and Captain Nosworthy were out reconnoitring in No-man's Land, which was at that particular place about 120 yards wide. They were about 20 yards from the German line when they heard groans, and discovered a German who had been shot through the eye. He must have been there at least three days, as the whole of his face was gangrened. It is difficult to understand why he had not been picked up by the enemy, as he was so close to their trenches. Be that as it may, the two Sapper Officers decided that they would carry him back to the British lines. This was easier said than done, as every time Major Sanders tried to lift him on to Captain Nosworthy's back, the wounded man howled with pain, and hearing his cries the Germans opened fire, which was immediately replied to from our trenches. At length after three attempts the man was brought in.

About three weeks later, Major Sanders and Captain Nosworthy were summoned to Brigade Headquarters, where they were confronted with a civilian, who had been sent by the Geneva Convention authorities to enquire into the circumstances of an "atrocity" which had been vouched for by many Germans. It was alleged that at a particular place and at a particular time a German had been first crucified and then shot by two men of the Indian Corps. Both time and place left no doubt that the above mentioned two officers were the culprits!

They were made to give their statement of the true facts of the case on oath, and a full account appeared later in "The Times;" but it appeared to them that the task of bringing in any further samples of the Teuton was one not lightly to be undertaken.

Rest. On the 23rd, the Company left the line, and marched in pouring rain to Vielle Chapelle, and thence, on the 24th, to Le Cornet Malo, where it rested until the 1st April. It then marched back to Bout de Ville, and from there, on the 2nd, to Le Flinque, where a sector of the line north of Neuve Chapelle was taken over.

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April, 1915.

Rue Tilleloy. Map 1. *Trench Work.* The first four nights of this period were spent, in conjunction with the 34th Sikh Pioneers, in joining up across the mouth of a re-entrant in our line. The Germans were very active, and greatly impeded the work by close range fire. Sapping had to be resorted to in the most difficult places, but the parapet had to be breast-high on account of the water-logged condition of the ground. The Company received a letter of thanks from the G.O.C. Lahore Division for this work.

Captains Pakenham-Walsh and Nosworthy were evacuated sick with measles on the 6th and 7th April.

Ordinary work of trench improvement, and provision of fire-steps, traverses, and shelters, etc., continued until the 13th April, when the Company went into billets at Bout de Ville. Lieutenant Hamilton rejoined this day. Though this was a period of nominal rest, some work was done at night preparing the La Bassée road for armoured motor-cars,* and one I.O.R. was wounded. Other work, such as the erection of an observatory in Vieille Chapelle Church, was also undertaken.

During this period Major Sanders handed over command of the Company to Captain A. D. Arbuthnot, R.E.; Captain K. Mason, R.E., joined; and Captain Nosworthy rejoined. Jemadar Ali Bahadur was transferred to the 21st (Fd.) Company, 3rd Sappers and Miners, with the rank of Subadar.

2nd Battle of Ypres. *Maps* 4 *and* 5.

On the 23rd, heavy gun-fire was heard from the direction of Ypres, and on the same day orders were received to take up the pontoons, which were in bridge at Busnes, 15 miles away, and to bring them to Bout de Ville. The Company meanwhile was to hold itself in a state of constant readiness. The pontoons returned under the charge of Sergeant Sprinks, R.E., at 6 a.m. on the 24th.

The Company marches north. At 2 p.m. on that day, the Company marched north with the Lahore Division to Mont des Cats. On the march the news was circulated that the Germans had used gas at Ypres, that the Allied line had been breached and that the Canadian troops were in a difficult position. On the 25th, the Company marched to Ouderdom. The roads were bad, and completely blocked in places by wagons, especially by those of a Field Hospital, which had apparently bivouacked on the road. Arriving at 4.0 p.m., the unit billeted for the night in a farm occupied by a disagreeable woman and her three loutish Flemish sons. Orders were then received that next

* These cars were commanded by Wilding, the tennis champion. He was killed in action on the La Bassée road on May the 9th.

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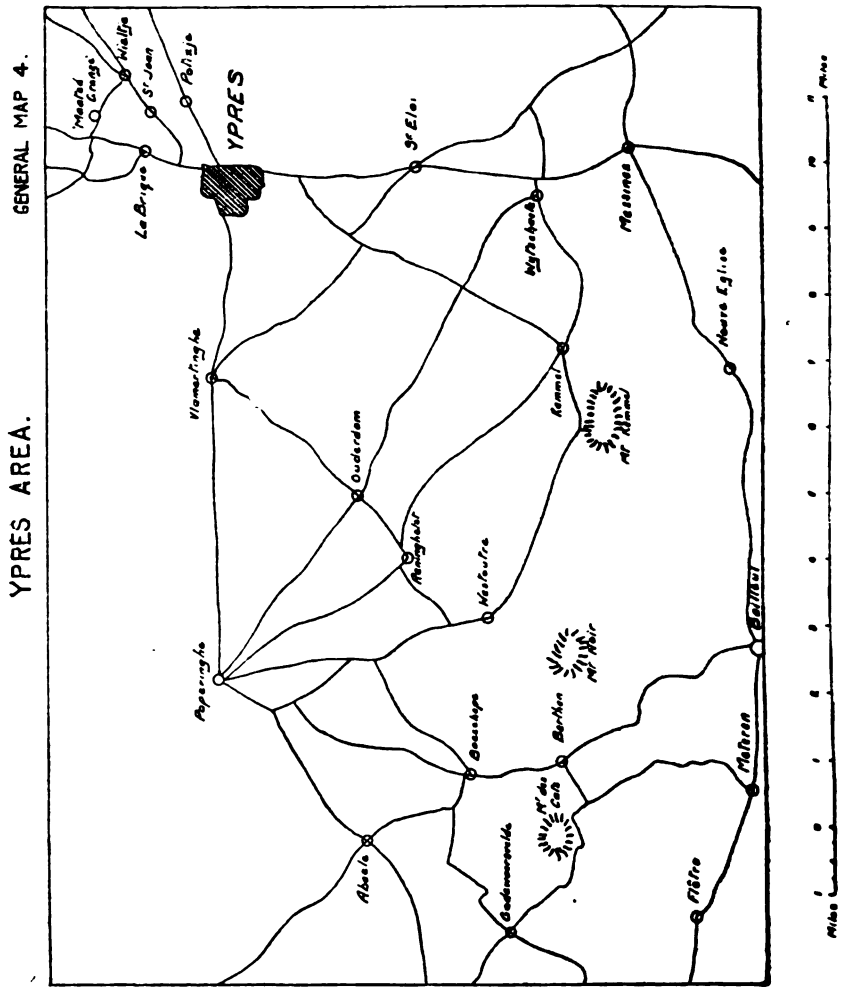
day the right half-company, with Captain Rawlence and Captain K. Mason, would be attached to the Ferozepore Brigade, and the left half-company, with Captain Nosworthy and Lieutenant Hamilton, to the Sirhind Brigade.



The Company marches through Ypres. At 5.55 a.m. on the 26th, orders were received that the Ferozepore Brigade was marching at 5.30 a.m. and the Sirhind Brigade at 7.30 a.m., and arrangements were made accordingly. Captain Arbuthnot proceeded with the pontoon section to a farm 1 mile west of Ypres. The remainder of the company marched at 6.30 a.m.

Shell Fire. The long column of the Lahore Division was observed by an enemy aeroplane as it passed through Ypres on the road to

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St. Jean, and the rearmost troops, among whom were the 20th and 21st (Fd.) Companies, came under heavy and accurate fire. One shell fell on the roof of a house just above the left half-company as it marched through Ypres, causing several casualties, and almost immediately other shells fell on the cobbled street with even greater effect. After a short period of disorganization the left half-company got through, having sent the wounded to the rear, with a loss of 20 men killed and wounded. An officer's charger and an ammunition mule were also hit. The right half-company, however, was luckier and passed through unscathed. Having emerged from the narrow streets of the town, the right half-company proceeded to the Ferozepore Brigade Headquarters at La Brique, while the left half-company was ordered to report to the Sirhind Brigade at Potizje.

Meanwhile Captain Arbuthnot, having left the 2nd line transport and pontoon section in bivouac, bicycled with three orderlies through Ypres to find the Company and report to Divisional Headquarters. The road was under heavy shell-fire. One orderly was injured by a falling house; and Sapper Hira Singh took him and his bicycle back to a dressing station, returning himself later for his own bicycle.

Counter-attacks. At this time the Ferozepore and Jullundur Brigades were making gallant, but unsuccessful, efforts to oust the Germans from the position which they had reached. The counter-attack had to cross open, rolling, grass-land, and came under fire practically as soon as it debouched from St. Jean. When the firing-line had approached close to the German trenches, it was met by a discharge of gas, whiffs of which reached as far back as Potizje, and the attack failed.

However, it had the effect of preventing a further German advance.

Dug-outs in Potizje. Map 5. That night the left half-company settled down in rough shelter-trenches in the grounds of the Chateau of Potizje, while the right half-company made a defensible post in co-operation with the 34th Sikh Pioneers.

By the end of the day the following casualties had occurred:—

Wounded .. .. .. Jemadar Nur Alam, and 1 R.E. driver.
Killed and wounded .. 28 Indian other ranks and 1 follower.

Captain Rawlence was now transferred to the 21st (Fd.) Company to replace casualties.

Results of Shell-fire. At this time the buildings in and around Ypres were almost intact. The Cloth Hall had suffered, but otherwise the town and its suburbs were comparatively little damaged. To the west of Ypres the cottages, villas, orchards, and gardens, were strongly reminiscent of any English country town. The Chateau of Potizje, in the grounds of which the Company lay, was

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almost intact. The rooms were as their owner had left them, with paintings on the walls and carpets on the floor, and the drawers full of feminine garments disordered in the last search for trifles easy to carry away. During the next week, buildings and churches crumbled before the men's eyes under the converging bombardment from north, east and south, which the enemy maintained by day and by night. The German gunners were using heavier shell than had hitherto been seen by the Indian troops; and one, a 420 mm. howitzer shell, was unmistakeable as it passed overhead, rumbling like a train, to fall either in Ypres or Poperinghe far in the rear. St. Jean, with its conspicuous church, provided an easy target for the German gunners, who soon found the range; and, before the Company left Ypres, both church and village lay in ruins.

April 27th. Map 5. On the 27th, another abortive attack was made by the Lahore Division, in conjunction with the French on the left. A party of the Company was held in readiness to assist if required. Though heavily shelled, the party suffered no casualties, but the Headquarters of the Sirhind Brigade, close at hand, had heavy losses. The right half-company meanwhile constructed dug-outs for the Headquarters of the Ferozepore Brigade.

That night the left half-company improved the trenches in the neighbourhood of F.—F., G.—G. The trenches had hitherto been somewhat embryonic, and a certain amount of work was carried out with the object of joining isolated lengths of fire trench, and providing communications. While work was in progress, Captain Nosworthy reconnoitred the line and "No-man's land," and explored the Moated Grange, which lay between the opposing lines. During the 27th, Captain K. Mason and 2 Indian other ranks were wounded.

Meanwhile Captain Arbuthnot had brought up trench stores to a point half-a-mile S.S.E. of La Brique. His party was heavily shelled, and Sergeant Sprinks and the British drivers distinguished themselves by their coolness in unloading the stores under fire.

Night of 28th-29th: New Line Dug. On the 28th, Captain Arbuthnot arranged to bring up stores for both Companies, leaving Captain Rawlence, of the 21st (Fd.) Company, and Captain Nosworthy to supervise actual work in the trenches. In default of a field engineer to co-ordinate work, this arrangement was essential. However, Major Boileau, R.E., and Captain Stack, R.E., field engineers, arrived unexpectedly that evening, and work was accordingly arranged for the Sappers and Miners and Pioneers. But at the last minute a weak Canadian Infantry Brigade was lent to the Lahore Division as a digging party, and a more ambitious programme was undertaken. The Canadians were put to work on a new trench

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H.—C.—K. by Captain Nosworthy and Lieutenant Hamilton. The Pioneers dug a communication trench; while the 20th and 21st (Fd.) Companies worked in the Moated Grange, which was prepared for an all-round defence, wired, and provided with communication trenches to the cellars.

This new line joined the French positions at French Farm with our own, and ran in advance of our old front line for some distance. Lying below the German trenches, which were on rising ground, it was concealed from them to a certain extent by the convexity of the ground. It was heard later that when the enemy renewed their attack, after the Lahore Division had left Ypres, their gas cloud passed over the heads of the British Infantry in the front line trenches, and the attack was beaten off with heavy loss. The position, therefore, was happily chosen.

It was bright moonlight, and the Germans could be seen above against the sky-line, briskly engaged in wiring their position. Being themselves thus busy, they did not hinder the work to any great extent by their fire. Unfortunately, during the course of the night, Captain Nosworthy, who had gone with Lieutenant Hamilton to reconnoitre the French dispositions near French Farm, was shot through the breast by a Canadian of the covering party. It was some time before the man, a very raw recruit, could be convinced that his victim was not a German. A stretcher was not immediately available, and a long time elapsed before Captain Nosworthy could be taken to the rear. Badly wounded as he was, however, on meeting Major Boileau on the way back, he insisted on explaining the position of the French to that officer. Captain Nosworthy, though shot through the heart, eventually recovered, but never rejoined the Company. His loss was deeply felt. This day, in addition, one Sapper was killed and four wounded.

On the 29th, the front line trenches were handed over to the 13th (British) Infantry Brigade, and the Field Companies of the Lahore Division ceased work in the front line.

April 30th. On the 30th, the German bombardment continued, and eight more men of the Company were wounded. On the 1st May, the Company moved to trenches half-a-mile north of Potizje to avoid the shelling. It is unfortunate that they did not move before, as Potizje was little else than a death-trap. The ground between St. Jean and our front-line was not so heavily shelled, and a position could have been chosen where dug-outs could have been made concealed from the enemy's observation. The 21st (Fd.) Company occupied dug-outs in this area, and suffered much less, though their mules, which were in Potizje, were decimated.

May 1st. On the afternoon of the 1st May, the French made an effort to advance on our left, supported by the artillery of the Lahore Division, but failed to make progress.

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The Company leaves Ypres. That evening the Company received orders to march to Ouderdom partly along the railway-line and partly by road, passing south-east and south of Ypres, in order to avoid the shelling. Very early on the morning of the 2nd, the Company reached Ouderdom, and went into its former billets there. Owing to casualties among mules, some equipment had to be left in Ypres, but this was recovered on the 2nd by Captain Pakenham-Walsh, who had rejoined the day before.

Losses. So ended the Company's experiences of Ypres. In six days it had lost nearly 60 of all ranks,* all of whom, except Captain Nosworthy, were put out of action by shell-fire. Apart from the line dug on the night of the 28th—29th, little useful work had been done. This, perhaps, was unavoidable, as the French were confident that they could drive the enemy back; and it was not expected that the British position in front of St. Jean would be permanently held. No co-ordinated scheme of consolidation was, therefore, evolved.

These losses undoubtedly hit the Company very hard. Many of the best N.C.O's. and Sappers were permanently lost, and after this time a man who had come to France with the Company was almost as rare as he was in 1918.

After this fighting, Sir Horace Smith-Dorrien and Sir Herbert Plumer addressed letters of thanks to the Lahore Division for their work in Ypres.

Return to the Neuve Chapelle Sector. *Map* 1.

Trench-work, May, June and July, 1915. On the 3rd May, the Company marched to Metteren, and on the night of the 4th—5th, to Bout de Ville, where it remained until the 24th July. Lieutenant A. Mason, R.E., and 2nd Lieutenant Venables, I.A.R.O., joined about the 5th May. Captain Pakenham-Walsh had been evacuated sick on the 4th.

On the 9th May, an unsuccessful attack was made on a front extending from a point not far South of Neuve Chapelle to Givenchy, but the Company was not engaged.

During the ensuing period the Company worked hard by day and night on the defences in the Neuve Chapelle and Rue du Bois Sectors. The weather was pleasant, however; the enemy was inoffensive; and casualties were light. The work done need not be mentioned in detail. It is sufficient to note that materials were forthcoming in ever-increasing quantities, and that types of dug-outs, machine-gun emplacements, revetments, etc., were becoming

* The War Diary, which was written after leaving Ypres, is incomplete as regards records of casualties. Captain Hamilton remembers that Captain Arbuthnot, when making out A.F.B. 213, mentioned that the casualties were nearly 60. Captain Rawlence, whose memory is to be trusted, gives them as 57 or 58, and 31 for the 21st (Fd.) Company.

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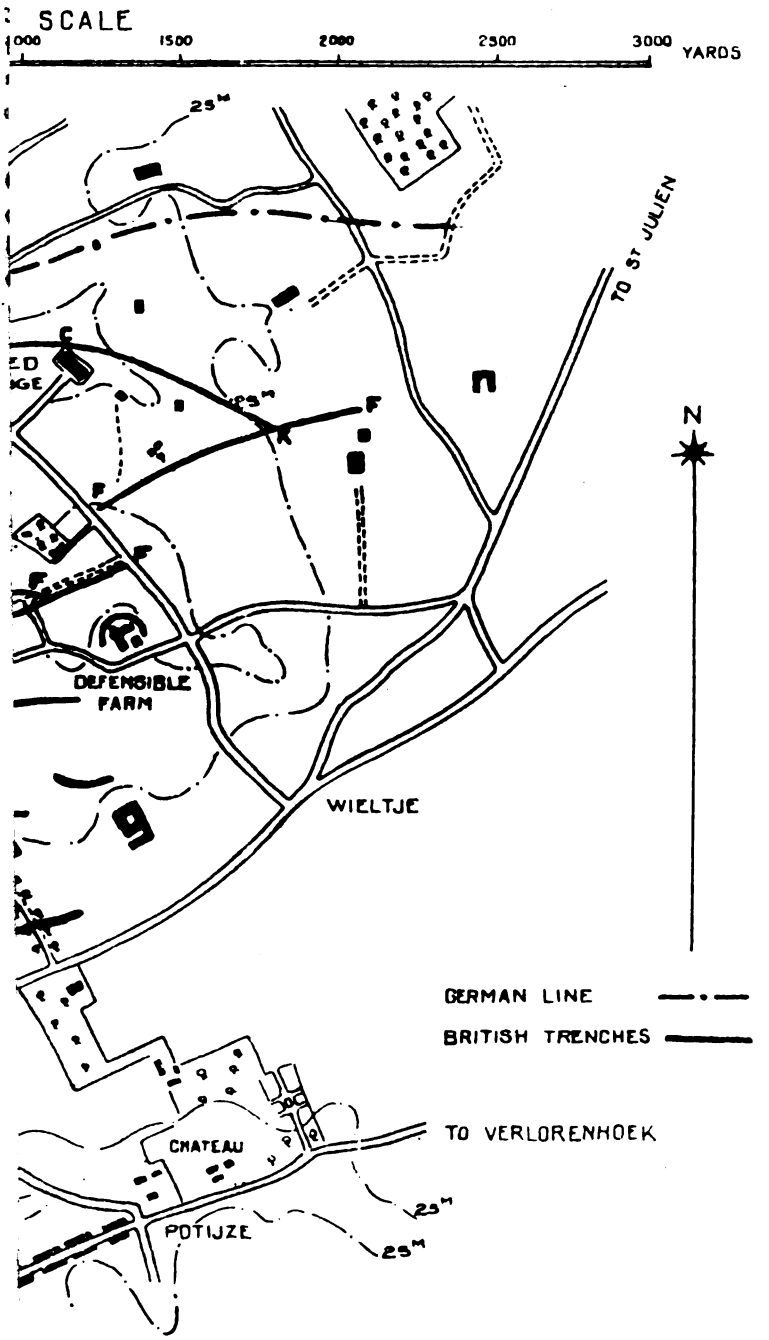
AREA - APRIL 1915.



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standardised, and provided in bulk by corps workshops. The Sappers were no longer expected to manufacture bombs, nor to do non-technical work for the Infantry, which the latter had now learnt to do for themselves.

Amongst other work, Port Arthur, a ruined and conspicuous brewery or sugar-refinery, on the La Bassée road not far behind the front-line, was fortified as a strong point. It afforded an attractive mark to the German gunners, and the Company was lucky to suffer only a few casualties there.

Rest at Le Forêt. From the 24th July to the 2nd August, the Company, less 1 section, went into rest billets at Le Forêt. The detached section, having spent a few days at Berguette, constructing bomb-proof shelters for explosives, rejoined in time to participate in combined sports held by the 20th and 21st (Fd.) Companies. The weather was delightful, and a thoroughly enjoyable time was spent.

August, 1915.

Trench-Work.—On the 2nd August, the Company returned to Bout de Ville and its former work in the vicinity of Neuve Chapelle, and remained there until the 26th, when it moved to Lacouture. and started to put the village of Richebourg into a state of defence, This work continued until the 6th September, on which date the Neuve Chapelle sector was again taken over.

Battle of Loos: September, 1915.

Preparations were now put in hand for the offensive of the 25th September: telephone cables were buried, observation posts constructed, sally-ports mined through our parapets, and an emplacement for a 3-pr. Hotchkiss gun, belonging to an armoured-car detachment, made in the front line trenches. Meanwhile officers reconnoitred, as far as they were able, the German lines, and studied the location of the strong points which would have to be constructed behind the German lines in the event of our attack proving successful.

On the 25th September, the two sections with Lieutenant Hamilton and Lieutenant Venables, were placed under the orders of the C.R.E. Meerut Division, and remained in trenches to the rear of the Rue Tilleloy. They were not required, however, as the Meerut Division, having broken through the German trenches under cover of a heavy bombardment, and the surprise effect of a mine, were driven back into our lines by a counter-attack from one or both flanks. The day ended in depression and pouring rain; and the two sections marched back to billets. The remainder of the Company had meanwhile stood in reserve at Pont Logy behind the Lahore Division, which was not used in the attack.

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OCTOBER, 1915.

Smoke-Cloud.—Work now continued as before.

On the 13th October, the Company co-operated with the Lahore Division in a feint attack, designed to assist the efforts of our troops at Loos. Thirty-two boxes, each containing 5 pounds of red phosphorus, were carried down to the trenches and placed in sap-heads. Disaster was nearly caused on the way when one box caught fire and was with difficulty extinguished. At zero hour the phosphorus was lit, and our guns opened a heavy bombardment. The Germans were very alarmed, evidently suspecting a gas attack, and put down a dense barrage, which did not cease until some time after the thick clouds of smoke had cleared away. This was in many ways quite an effective operation, but the losses among the Infantry, who held the front-line trenches in force throughout, were somewhat heavy. Two Sappers were wounded.

The Company had, on the 3rd October, moved to Riez Bailleul, where a peculiar occurrence took place. The company interpreter, a Frenchman named Carron de La Carriére, occupied a room in a billet by himself, and awoke one morning to find his wallet opened, and his identity papers abstracted. Four hundred francs in notes, which were also in the wallet, were untouched. Enquiries were instituted, and a succession of Intelligence officers, both British and French, visited the unit without apparent result. There is no doubt that at this time there were many spies behind our lines, and some French inhabitants were not above suspicion.

Wet weather sets in. The weather now became wet and cold, and the Indian troops looked forward without any great enthusiasm to another winter in the mud. The sub-soil water-level again began to rise, and raised trench-boards were, therefore, put down, and the drainage of the trenches taken in hand. In some places high-level communication trenches with revetted parapets were constructed to replace the low level ones which had done duty during the summer.

NOVEMBER, 1915.

The Lahore Division leaves the line. As October drew to a close, the rain became more frequent and heavier; and it cannot be denied that all ranks were greatly relieved when they marched, on the 28th November, to Mametz and said "good-bye" to Neuve Chapelle for the last time.

The two Companies of the 3rd Sappers and Miners prided themselves somewhat on their work in and around Neuve Chapelle, and accordingly a notice was erected in the advanced R.E. Dump, drawing attention to *Ecclesiastes* 11, 18 and 19, which accurately portrayed their sentiments.

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On the 25th November, representatives of the Indian corps paraded, and were given the farewell message of His Majesty the King Emperor by H.R.H. the Prince of Wales, an honour which was much appreciated.

DECEMBER, 1915.

The Company Embarks for Mesopotamia. On the 1st December, the Company marched to Honenghem, where it was drilled and trained, and on the 13th, less the transport under Lieutenant Hamilton, it entrained at Berguette for Marseilles. At the latter place it embarked for Mesopotamia on the S.S. "Franconia." As will be seen, the transport did not rejoin the Company until many months later. This failure to send transport with the unit to which it belonged greatly handicapped the Company in its work in Mesopotamia.

The pontoons were left behind in France, but the R.E. drivers and their animals accompanied the remainder of the transport to Basrah, where they were attached to a bridging train. These drivers were a fine lot of men, and got on well with the Indians. Corporal Clark, however, an invaluable N.C.O. and excellent horse-master, was retained by some means or other. "Nabi" Sahib, as he was called by the men, did not leave the Company until after the Armistice, as has already been mentioned.

RESUMÉ.

Thus ended the Company's period of service in France, during which time 200% of officers and nearly 100% of men became casualties. In a strange country, and under conditions of which they had never dreamt in India, the men did their duty to the utmost of their powers. They left knowing that they had not tarnished the honour of the Third Sappers, and they hoped they had brightened it. Let their work be their witness, and the graves of their dead be not forgotten.

(To be continued.)

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"SHELL-FIRE VERSUS PERMANENT FORTIFICATION."

THE EVIDENCE OF VERDUN, 1916.

By LIEUTENANT H. B. HARRISON, R.E.

Verdun, the old Virodunum of the Gauls, built on a spur overlooking the course of the Meuse for a distance of twelve miles, has been from earliest times essentially a military town, and, being an important link in the chain of French frontier communications, has undergone frequent sieges.

In 1870 the only defences the town could oppose to the Prussians consisted of the old fortifications of Vauban, but the re-organization of the French Eastern frontier after 1870 resulted in Verdun becoming the northern pivot of the great defensive line Toul—Verdun, and in order to enable the town to carry out its rôle a series of fortified positions was constructed from 1874 onwards, stretching further and further afield as the range of artillery increased.

Between 1874 and 1880 a ring of detached forts was built, the forts being at distances of from 1½ to 4 miles from the town. Those on the right rank of the Meuse being Belleville, St. Michel, Souville, Tavannes and Belrupt, and those on the left bank Dugny, Regret, La Chaume and Marre.

After 1880 this initial defensive system was completed by the construction of a number of new works built on dominating positions varying from 3 to 5 miles from the town. On the right bank were built Douaumont, Vaux, Moulainville, Rosellier and d'Haudainville, and on the left bank Landrecourt, Sentelles, Chana, Choisil and Bois Bourrus.

The protection of all these forts as originally built consisted solely of plain masonry covered with a thick layer of earth, but on the introduction of the high-explosive shell the earth, covering the masonry, was replaced by a layer of cement concrete about 8 feet thick with a cushion of three feet of sand between the concrete and the masonry. The process of this replacement was begun in 1885, and by 1897 the majority of the forts had been thus strengthened, while in addition the intervals between the forts were supplied with batteries in open emplacements and with fieldworks, of which several such as Froideterre, Thiaumont, La Laufée and Charny, were later converted into permanent works and considerably reinforced.

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In 1900, owing to the increasing power of artillery, the forts were further strengthened and, from now on, reinforced concrete was the material used, the walls and roofs of the casemates being given thicknesses varying between 4 and 5 feet.

In 1905, work was begun on installing disappearing gun turrets, armoured observation posts and Bourges casemates.

The forts, then, in 1914 can be classified into three distinct categories :—

(*a*) Those built before 1885 and not subsequently modernized, consisting of blocks of masonry 3 to 4 feet thick covered with a layer of 6 to 15 feet of earth.

(*b* Those built before 1885, and subsequently modernized, consisting of the masonry as before, strengthened with up to 8 feet of concrete with an intermediary layer of 3 feet of sand.

(*c*) Those protected with reinforced concrete 4 to 5 feet thick.

When studying the effects of enemy shell fire on the forts we will consider the above three categories separately.

The total armament of the forts, in August, 1914, consisted of the following :—

6 disappearing turrets for 155mm. guns for long range fire.
14 disappearing turrets for 75mm. guns for close range fire.
23 Bourges casemates for covering the intervals between the forts.
210 machine guns for use either in the forts or in the intervals.
670 guns divided into 130 batteries, placed outside the forts for long range and counter-battery work.
68 steel or concrete observation posts.

The ammunition, 800 rounds per gun, was stored in 8 magazines cut out of the rock and linked up with distribution dumps and gun emplacements by a 60 cm. Décauville light railway.

Finally, in the intervals between the forts of the outer ring, were constructed 16 concrete shelters, each to hold one company of infantry and 18, each to hold half a company.

Such, then, at the outbreak of the war was the permanent defensive organisation of Verdun, a fortress to be defended to the last and with the following three-fold rôle to play :—

(1) To hold the lines of approach along the Meuse and to cover, in part, the concentration of the field forces.

(2) To assist any offensive movement of the French troops in the Woevre and to assure their communications.

(3) To facilitate their retreat in case of defeat, to draw off a portion of the enemy forces, and to harass his communications.

The Great Test.

The early days of the Great War witnessed a complete change of opinion as to the value of permanent fortification.

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By an Army order of 9th August, 1915,* the forts of Verdun were stripped of guns, ammunition and war material, the whole of which was handed over to the field forces, the order stating that the forts were in future only to be used as shelters for reserve troops. An annexure gave the following reasons for this decision :—

(1) Before the powerful destructive effect of modern artillery permanent defences will inevitably be destroyed. Proof of this has been given by Liège, Namur, Antwerp, Maubeuge, and by the rapid fall of the great entrenched camps in Russia after the retreat of the field armies.

(2) The violence and length of bombardments essential both in attack and defence entail an enormous expenditure of ammunition, the continuous supply of which to an invested fortress is practically impossible.

(3) An invested fortress must then eventually surrender to the enemy its garrison and its supplies not expended or destroyed.

(4) Under these conditions the defence of a country depends solely on the field armies.

It is accordingly only logical to hand over to these armies the resources that would inevitably be lost in the fortresses.

As a result of this order the organisation of fortresses was changed. Whereas, before, they had had their own commanders and had been partially independent of the Commander-in-Chief, they were now placed directly under the latter's control and were to be made use of by him as the military situation demanded. Their permanent works were absorbed into the successive lines of field defences, and the rings of forts were no longer considered circles of defence round one central position. Henceforth in no case was a fortress to be defended to the last solely for its own sake.

In short, it appeared that the gun had at last gained a definite ascendancy over permanent fortification.

When, then, the German attack on 21st February, 1916, was launched, we find all the forts empty save for demolition parties ready to prevent the works falling intact into enemy hands.

This state of affairs lasted exactly five days.

On 26th February the Germans entered Fort Douaumont without opposition.†

The same day General Pétain took over command of the Verdun

* By Government decree of 5th August 1915, the French fortresses were declassed as such. Their Commandants hitherto responsible direct to the Government were, with the garrisons, assimilated to the field troops and placed under the C. in C. in the field.

† Orders had been given for the re-occcupation of Fort Douaumont. But instead of getting them out promptly, the staff concerned waited whilst a draughtsman copied a sketch to be attached to the orders. Meantime an adventurous party of Brandenburg Grenadiers under a Lieutenant, who had been ordered to advance as far as the wire of the fort, seeing it apparently empty, entered it unopposed.

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district and he at once gave orders for the complete re-arming of all the forts. His own summing up of the situation is as follows :

" Les forts et ouvrages de l'ancienne place de Verdun, en raison de la valeur de l'obstacle qu'ils présentent, des observatoires et des abris qu'ils fournissent, ont une importance considérable au point de vue de la défense des secteurs. La défense de ces forts et ouvrages doit être organisée par les généraux commandant de groupement, de sorte que, même investis, ils puissent continuer à résister. L'expérience des derniers combats a permis d'apprécier la capacité de résistance des forts. Ceux-ci sont en effet mieux organisés que les points d'appui créés hâtivements sur le champ de bataille (emplacement et tracé étudiés à loisir, flanquements soigneusement organisés, abris tres profonds et betonnés, etc. . . .) et ne constituent, pas plus que les localités, des ' nids à projectiles,' puisque leur superficie est souvent égale à ces dernieres. Les forts donc peuvent et doivent être utilisés partout pour la défense des secteurs."

In short, the considerations that led to the framing of the order of 9th August, 1915, were now shewn to be entirely ill-founded, and the re-armed forts re-assumed their original role.

For the purposes of studying the part played by the forts and the effect on them of the enemy fire, it will be sufficient to study the right bank only of the Meuse, as it was on this sector that the main German blow fell.

At the beginning of the enemy offensive fn February, 1916, the front line formed a semi-circle to the north of Verdun of radius about 10 miles. Behind this front line on the right bank of the Meuse the French had four main lines of defence :—

(1) From Samogneux to Bezonvaux by way of the Bois des Fosses and the Bois la Chaume.
(2) Côte du Talou, Côte du Poivre, Louvemont, Douaumont, Vaux, Damloup.
(3) Côte de Froideterre, Ouvrage de Thiaumont, Fleury, Souville, Tavannes.
(4) The ridge held by the forts Belleville and St. Michel.

The following summarises the chief stages in the battle of Verdun in which the forts played a definite role :—

21st February.	Beginning of German attack.
26th February.	Fall of Douaumont.
22nd May.	Abortive counter-attack against Douaumont. The French held the superstructure of the fort for two days while the enemy held out underground.
7th June.	Fall of fort Vaux owing to the garrison running short of water. The enemy had been in possession of the superstructure for 5 days.

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23rd June. German attack on Froideterre, Fleury, and Souville. The enemy occupied the ruins of Thiaumont but was held up in front of Froideterre by the fire of the 75mm. guns from this latter work. Fall of Fleury.

12th July. German attack on Souville. Unaided, the garrison repulsed the assault several hours before the arrival of reinforcements.

On 1st July the Franco-British offensive on the Somme was launched and from that moment the German attacks became weaker and weaker and finally died away altogether.

24th October. Recapture of Douaumont.

3rd November. Recapture of Vaux.

During the whole of the German offensive the forts, constructed with a view to resisting artillery only up to 270 mm., were subjected, by guns of all calibres up to 420 mm., to a bombardment that surpassed in intensity anything that had been previously imagined.

In reply to the German fire the French fired between February and August, 1916, an average of 100,000 shells per day or a total of approximately 23 million shells in the seven months.

This gives one an indication of the storm of projectiles to which the forts were subjected, and which, nevertheless, they weathered in a remarkable fashion.

The Effects of Shell-Fire on the Forts.

Visiting Douaumont and Vaux, the two forts that suffered the most severely, one expects to find them completely demolished in view of the utter destruction of everything in the vicinity. On entering them, however, it is surprising to find the extent to which the concrete has held.

The effects of the bombardment on the forts on the right bank of the Meuse can be summarised as follows :—

(1) The effect on Casemates and Shelters.

category (*a*) Those consisting of blocks of masonry 3 to 4 feet thick covered with 6 to 15 feet of earth.

These have collapsed under shells of 210 mm. calibre or over.

category (*b*) Masonry strengthened with up to 8 feet of concrete with a 3 feet layer of sand in between.

These have held ; but in several places where the concrete is less than 6 feet thick they have collapsed under shells of 420 mm. calibre.

category (*c*) Those protected with reinforced concrete 4 to 5 feet thick.

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Anything less than 380 mm. calibre produced no effect. The 380 mm. shell had more effect on this category than on (*b*). Under projectiles of 420 mm. calibre they collapsed where the reinforced concrete was less than 5 feet.

It would appear that category (*b*) owes its superior resisting power in the case of the 380 mm. shell to the layer of sand which acts as a cushion damping down the vibrations set up by the explosions.

The weakness of the reinforced concrete seems to lie in the fact that when a heavy shell explodes the concrete and the reinforcement vibrate with different intensities, thus tending to separate the two.

(2) Effect on Armour Plate.

The machine gun turrets were only constructed to withstand shells up to 150 mm. These they have resisted, but anything bigger destroyed them.

The turrets for the 75 and 155 mm. guns generally resisted well, shells as a rule ricochetting off them.

At Douaumont a shell of 380 mm. calibre fell directly on a 155 mm. turret without causing the gun to cease fire.

The turrets in the forts during the battle of Verdun fired altogether about 8,000 rounds of 155 mm. calibre and 17,000 rounds of 75 mm. calibre. In general they reserved their fire for critical phases in the battle.

(3) Effect on Earthworks and Obstacles.

Under a medium bombardment, including shells up to 380 mm. calibre, earthworks and obstacles were seriously damaged though not rendered absolutely useless.

Under a violent bombardment, including shells up to 420 mm. calibre, they ceased to exist.

The condition of Fort Dôuaumont as the French found it after its recapture on 24th October, 1916, is very interesting. Out of the 18 casemates in the fort, 13 were still in good order: the 75 mm. and 155 mm. gun turrets were practically undamaged and were rapidly brought into action again: and this although 120,000 shells had fallen on the fort since the beginning of the German offensive, 3,700 of which were of 155 mm. or over and 400 of 370 mm. or 420 mm. calibre.

Conclusion.

Such was the rôle played by Verdun. Whereas in the early days of the war the Belgian fortresses had failed to fulfil their rôle chiefly owing to lack of liaison with the field armies and to faulty construction in their defences, Verdun on the other hand, with more strongly constructed forts and with the intervals between the forts elaborately organised, proved what a valuable asset to the field armies permanent fortification can be.

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The chief lesson to be learnt is that a fortress of the type in use before and during the war is doomed once it is cut off from the field forces and completely invested: a permanent work by itself cannot stand.

The pre-war theory that a frontier could be defended by a line of isolated fortresses is no longer tenable, and it must be replaced by a system of fortified areas, inter-connected and stretching the whole length of the frontier, taking advantage of all natural obstacles such as mountains and rivers and the sea.

In short, the permanent fortification of the future will be but the deliberate application of the principles of field defences as established during the Great War.

As it is unlikely, chiefly owing to financial reasons, that a complete defensive system could be prepared along any frontier during peace time, it would appear that the defensive organization of a frontier must be divided into three categories.

(1) A detailed plan of defence completely worked out on paper.
(2) The preparation and execution during peace time of elaborate defensive works on essential positions along the frontier.
(3) The preparation for the execution of the remaining works on the mobilization of the army. This would include—
    (*a*) Construction of railways to the points to be defended.
    (*b*) Collection of essential materials in dumps ready to hand.
    (*c*) A completely worked out programme for mobilizing the factories and workers needed for carrying out the works as rapidly as possible.

In conclusion, the change in permanent fortification as a result of the Great War only follows the natural evolution of fortification through the different periods of history.

As the organization of the intervals was the logical sequel to the system of detached forts, so the organization of the intervals is the logical sequel to the system of detached fortresses.

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THE LAST DAYS OF THE IRISH COMMAND.

Some Personal Reminiscences during 1921-22.

By Major-General G. Walker, C.B., C.B.E., D.S.O.

In what follows no mention will be found of politics, nor of the many theories propounded by divers experts on the subject of Irish Government. My object in writing is only to record some personal experiences, which will give some idea of what British Army life was like during the rather unpleasant time it put in, in Southern Ireland, immediately prior to the creation of the Irish Free State.

In the autumn of 1920, just after I had witnessed the public funeral in London of the victims of the 21st November murders in Dublin, I received a message from a female rélation in Ireland telling me that I was going over there. I was at the time C.E. of the London District, had just been promoted substantive Colonel, and had also been told that I was confirmed in my appointment, which had previously been called "temporary" in the official jargon of the Army List. I was consequently looking forward to getting a settled home in London after wandering about the earth since 1914.

The information came as a very distinct shock, and, do what I could, I could not find out if it was authentic. The people in Ireland said "every one knew it," and yet I had been told nothing officially. I did not want to ask either, as I did not want to do anything likely to put such a move into the heads of the powers that settle such matters.

I did not want to go a bit, as I was what is called an Irishman, and nearly all my relations lived over there. I tell all this to show how secret things get abroad apparently. The rumour was true enough, as in due course I got the letter asking me if it would be agreeable to me to go to Dublin as C.E.? I promptly said it was not in the least agreeable, and gave many, as I thought, good and sufficient reasons why it would be much better to send someone else. However, I said I could not refuse if "They" particularly wanted me, and "They," having satisfied themselves that I was not a politically marked man in Ireland, sent me over.

I immediately received all sorts of complicated orders as to how I was to disguise my errand (not my person). I was not to have a warrant but buy a ticket; I was to carry a "gun," but on no account was it to be in my luggage, etc. My first trouble was how to acquire a gun and get a permit to carry it into Ireland. This

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latter was necessary, as, if the British Customs people at Holyhead found it on me, I being in plain clothes, there was trouble in store.

I made many efforts to get this permit. W.O. absolutely declined to give it for some time, and it was only when it was pointed out to them that their orders could not be obeyed without it, that they relented. Their first plea was that Irish Authorities should issue it, and it was only after a rather heated telephone conversation between myself and a youthful Staff Officer, in A.G. something or other, that I won my battle. So much for secrecy—every telephone lady in London knew I was going to Ireland and that I wanted to take a "gun." I often laughed over this incident later, but it annoyed me at the time.

I started on 18th February, 1921, by the Irish Mail, all my luggage being labelled with my name alone, no rank. Some people said I ought to have had an alias! On my arrival at Kingstown, on the morning of 19th, I found things looking pretty ordinary, except for the sentry on the end of the pier. My luggage was tackled by a frowsy porter much as usual, and poor old Davey was there with his armful of papers. A car had been sent to fetch me, and it was only after we had started in this for Dublin that I began to realise that the rebellion was really a going concern. The chauffeur was in plain clothes, but the appearance of the car (a Sunbeam) left no doubts as to its ownership. My Jehu was a Jehu indeed, and drove like the devil, putting the heart across me, to use a local phrase, properly. I made sure we should kill someone *en route*. All the military drivers I found drove like this, and I can remember telling one of them later on that I preferred taking my chance of being shot by a "Shinner" to making a certainty of death by driving at his pace. He seemed rather crestfallen but after that I had no trouble with the drivers. Our drive of eight miles ended without incident, and we arrived safely at Ross's Hotel, where I was to live.

I got down and rang the bell, and the door was first opened on the chain by an armed soldier, who inspected me before he admitted me. On getting inside I found another soldier in the hall, with his loaded rifle and bayonet at the "charge" waiting for me. A nice welcome truly, but it was the ordinary routine which was gone through whenever any of us either left or entered the house.

Ross's Hotel stood just at the end of Kingsbridge, and was opposite the Railway Station of that name. It has been abused by some people, but I must say that nowhere have I found people so anxious to make one comfortable, and, under the adverse circumstances, we were all very happy there. The hotel was about ¼-mile from the office, and this distance we had to walk every day, the road being patrolled by an armoured car the while. The hotel was much defended with barbed wire, and we also sported a sentry and, I believe, a machine gun on the roof. Our outlook in front was

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open enough, but at the rear we were overlooked and shut in by a host of small squalid houses, and if we had been attacked in that quarter we should have had a warmish time. Why we were not attacked I don't know. I expect the reason was that the rebels knew we were ready for them, and a "Shinner" seldom dared to tackle anyone who was prepared.

We had all sorts of mobilization orders and alarm posts. One of the orders was that, if alarmed at night, everyone was to don a "Coat British Warm." The idea being that this garment was more identifiable than parti-coloured silk pyjamas. I remember being much entertained one night at the appearance, on a false alarm, of a very senior Colonel dressed in this garb, with his hair on end and his eyes half open (he had been rudely awakened), and a large revolver in his hand. He had gone to bed early, and I, with three other irreclaimables, was playing bridge; somebody had started firing out in the street, probably at nothing, and our sentry on the roof was not to be deterred from his share in the sport. Nothing came of it, and so to bed about 1 a.m.

I am not sure that the cause of this adventure was not the gallant press officer at G.H.Q. I know that one night he was returning from the Kingstown Yacht Club in his Ford car and failed to hear the challenge of a sentry near our hotel (the car was not of the silent order). The sentry opened fire at once, such were their habits, and the guard turned out and did likewise. I know the press officer told me that as he fled up the road to his quarters in the "Rat Pit" (Soldiers' Home) he was followed by a cloud of fortunately erratic bullets. The Rat Pit was the abode of the more junior officers on the H.Q. Staff. It was the Soldiers' Home of more peaceful times, and as such was an admirably arranged institution. As officers' quarters it left much to be desired, as the bedrooms were mere cubicles; some of them were made to hold two officers. It may have been uncomfortable, but its denizens were a distinctly cheerful lot, to judge from their general demeanour.

Our life at Ross's was dullish. We worked from 10 a.m. to 5 p.m. with an interval for lunch, and then time hung pretty heavy on our hands. Bridge was my amusement after dinner, and we had a cheerful party enough. The bridge playing was diverted occasionally by scares such as I have alluded to above, and sometimes by comic interludes. I remember two of these in particular. The first was when our roof sentry suddenly fired a shot which was immediately followed by a female scream. This brought us to our feet quick enough. Another shot and a volley of bad language, followed by the expression "I won't be Curfewed," in a shrill female voice. I may here mention that to be "Curfewed" meant to be taken up by a patrol, if you were out without a pass after the "Curfew" hour. It meant a night in "quod" and a fine of 2/6 next morning,

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I am told; I had no personal experience. To continue, the sentry shouted "Come here, my dear," and the lady replied "I will not be Curfewed"; another shot, and so on until she was brought to the hotel door, when she was taken over by the guard and ultimately put into the Curfew lorry, which called about 11 p.m. This Curfew lorry furnished the other incident. One night we were at bridge, it arrived and we were disturbed by roars of laughter. On going to the window we were just in time to see a rather inebriated lady being shot into the lorry protesting vociferously. As soon as she was safely in, however, she seated herself beside the sentry inside, and him she proceeded to embrace affectionately, much to his annoyance and the merriment of the spectators.

Before I leave "Ross's" I must say a word about some defences I put up. When I arrived we used to play bridge in a bow window facing the street. There were no shutters, and if the blinds were not drawn we played in full view of the street. Even if the blinds were down the lighted window made what, to me, would have been a very tempting target. After some difficulty I got hold of some old boiler plates, which were about 2ft. wide, and we put them up across the windows. After that we sat in comparative safety, as any shot from the street which missed the top of the plates must miss the occupants of the room.

I have said life was dull, but we had some compensations; the first was travelling, of which more anon. The others were the Kildare Street Club with its squash court, and the St. George's Yacht Club at Kingstown. I think the Kildare Street Club saved my life. We used to go down by tram after office and play squash until dinner time, then a bath, then dinner, and sometimes we walked and sometimes taxied home. We went in plain clothes and were all armed. When we were playing squash we usually made up a party of four. Two to play and two to keep guard in the Gallery. The players' "guns" reposed in the corner of the court against the back wall; the spectators' guns were in their pockets. Similarly at the bath, one always had an armed companion in the dressing room and your own gun in the bath room. The trouble was that one never knew who could be trusted. There were, I know, many faithful men in the country, but one could not tell them by head mark, and unfortunate accidents had occurred owing to people being too trustful. I think our taxi drives home were safe enough, but I am not so sure of our walks. However, nothing ever happened. True, we were armed and never walked alone, but still, if they had wanted they could have got us everywhere. A "gun" is no use as a protection to oneself against an assassin; it only helps in case you see a friend being attacked. We were, I dare say, foolish, but we enjoyed it, and I should have gone dotty if I had had no amusement. I am afraid I went anywhere I liked, in trams and cars

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by myself, in plain clothes, with a gun in my right pocket, and I never had any ill-luck. I never could make it out, as I am sure I was known, in fact, I had evidence of this. For one thing, when my wife came over after the truce in July, '21, she was greeted by a tram conductor at Kingsbridge with "Welcome home, Ma'am, I hope you're well!" However, there it is; we did escape, and a miss is as good as a mile.

I think the Kildare Street Club was in those days the most comfortable club I have ever been in, and pretty cheerful too. The St. George's Yacht Club was a summer resort, which we began to frequent as the spring progressed. There, too, we were never molested, though we went regularly, and dined there sometimes. I know it was a rush to get dinner and get back before Curfew. Talking of the Yacht Club, I remember going out there to dine one night, after the truce, with Hugh Waller, my Staff Officer. We went by train and at a wayside station a man got in and stumbled over my feet. I did not look up from my paper at first, but I caught sight of Waller's face and noticed that it had turned rather pink! I then looked at the newcomer, who had seated himself beside me, and found that it was de Valera! The other people in the carriage looked as if an archangel had come among them. I am afraid my feelings were not quite the same. Dancing was another of the amusements, and dance festivals used to take place at intervals in St. Patrick's Hall in the Castle, in the afternoon.

I must now turn to the business side of the picture. The C.E.'s office was in the G.H.Q. buildings, and the staff I took over was extraordinarily well organised and efficient. There was any amount of money; in fact, more than could be reasonably spent, and we did not spend it all. The great trouble was the difficulty in getting about the country to see the C.R.E's. and works. Dublin was easy enough and so was the Curragh. I used to go about to these places in plain clothes by myself—the fewer the better I always thought. Ulster was easy too, though the train journey to Belfast was a trifle risky. At one time, in order to get to Belfast, I had to go via Holyhead and Liverpool, and thence by the direct sea route, a pretty costly business for the taxpayer! The West of Ireland was impossible without an escort. Cork had to be approached by sea. The usual way was to go by the destroyer that carried the military mail from Dublin to Queenstown, and thence by an armed launch to Cork city.

On arrival there, one was met by two armed motors, one for oneself and one for an escort, and this for a journey of a mile! Bere Haven, in Bantry Bay, was another place where a destroyer trip was necessary, though at first I believe they could go by train to Bantry.

To show the difficulty of getting about the interior of the Divisional

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Areas, I may mention a journey I made from Cork to Fermoy in the 6th Division Area, a distance of 22 miles. Something was worrying me at Fermoy and I said I must go. When I got to Cork I was told it was really not necessary for me to go, as Fermoy was quite happy. The trouble was that though Fermoy might be happy about itself, I was not happy about Fermoy. So I had, respectfully to insist. To make a long story short, I started at 9.30 a.m. inside a Rolls armoured car. Another similar car followed me with the C.R.E. 6th Division, and we were attended by a Crossley lorry containing 14 armed men! This for a joy-ride for two R.E. officers. We got there all right, except for a puncture on one of the Rolls. The outfit had to halt until this was repaired, and then I saw the object of the armed men. They picquetted the hills around. I sat on a bank and smoked.

As all the main road bridges were down we had to make a bit of a detour, and came across one double cut in the road. The cuts were about 3 feet wide and 3 or 4 feet apart. The Rolls negotiated the obstacle by following the track of the country carts down into the ditch beside the road and up again. I was much interested to see the facility with which this big car got over the difficulty. Our return journey was more dramatic. The Brigadier at Fermoy sent a 'plane to watch over us, as he said it was dangerous to return by the same route, and there was no other route open. This drew the audience properly, and I don't think there was a man, woman or child within running distance of the road that did not come out to see the procession. It's all very funny to look back on, but, with such precautions being considered necessary, it became a serious matter to offer an inspectional visit. The troops had quite enough to do without perambulating C.E.'s about the country. In fact, I found it impossible to try to see things in the bad places, and it was a useful lesson to learn that other people could get on without one's personal presence. One could only write and advise and encourage the C.R.E.'s to write their whole mind fully.

The money presented no real difficulty, as we decentralized thoroughly. We allotted the money to Divisional commanders, with authority to sub-allot to Brigade commanders. Each had a limited sum per item. The Divisional limit was £500, the Brigade £250. As long as they did not outrun the constable and stuck to these rules, they could go ahead. I was told by a high official in London that by this method I should bring ruin on the taxpayer, that my predecessor had been expensive, but words would not describe my character as a spendthrift if I pursued this policy. I said nothing, but I know I sent him back a handsome present in the way of a refund at Christmas, and I had a lapse in April. In other words, it worked extremely well when the G.O.C.'s. understood it. I was asked by one Divisional commander why he had been allotted

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so many thousand pounds. I asked him if he did not take an interest in the housing of his troops? He looked as if he wanted to bite me and said "Yes." I then explained that the money was given in order that he might put his desires into execution. Then he was all over it, though he said he would give his brigadiers no power, as he would rather have control of the money himself! That G.O.C. saved us thousands, and incidentally was quite happy and saved me a lot of what would have been quite futile worry. I can recommend this method of finance to anyone. In fact, it is based upon the principle that, if you want men to do their best for you, you must confide in them.

Talking of finance, I attended a conference in London once just before the Truce in July, 1921. The subject on which we were conferring was ways and means to carry out the engineer services of the campaign. Money was not the difficulty, as there was always plenty of that, but the people in England seemed to feel that we could not be trusted further than the peace regulations allowed. These regulations hampered us and made life very difficult. I was trying to get enhanced powers of making contracts for C.R.E.'s who were very isolated and who found that it was almost impossible to carry on under the rules. I persuaded all the members of the conference that my request was reasonable, with the exception of one civil member. He argued this point, and I got so tired of him that I opened fire in earnest, and told him that I did not understand his attitude of withholding reasonable power from men to whom the Government were willing to pay £1,200 a year. Either the C.R.E.'s were incompetent or he was wrong. I can see the chairman now, sitting with his head in his hands, in apparent despair as to what I was going to say next! My last barrage settled the business. I told my friend that his attitude indicated that he did not consider that British officers were to be trusted, and that I did not think that their conduct during the Great War gave him any justification for that opinion. That settled him and I won my point.

It would be almost impossible to give a detailed account of the work we had to do. It ranged from improving existing barracks, and bringing them up to modern standards, to housing troops in huts where no accommodation existed and providing lighting and drainage. Some of these hutments were for a whole battalion, some for a company. Another class of work was making billets, in breweries, poorhouses, old prisons and country houses, suitable for military occupation. The principal troubles in such places were lack of bathing facilities, warmth and light. It must be remembered that the troops were having a rotten time, and everything that could be done had to be done to make them comfortable. Besides this, certain schemes for building additional officers' quarters for

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married officers were in hand at the Curragh and Fermoy. Personally I think we were undertaking too much. It would have been wiser to have concentrated on the war services, and left the existing barracks alone until the war was over. The sequel proved this opinion to be correct, as, when we handed over our barracks on the evacuation in 1922, they were, with few exceptions, burned down during the internecine strife between the Republican and the Free State parties, and all our improvements were lost. Heaven only knows how many millions of pounds' worth of public property was destroyed at this time.

A word must be said as regards the actual evacuation. As a preliminary, we made out lists of all property, machinery, stores, etc., that were to be handed over. The Free State authorities guaranteed to take over and sign for this stuff, and, I believe, to protect it. When the British troops moved, the R.E. had to hand over and I gave particular instructions that on no account was there to be any hurry, and that the Free Staters were to be given every facility. In large places the handing over had to commence before the move, as we could not risk leaving isolated individuals behind to hand over. In most cases I think the taking over was perfunctory and the Free State signed blindly. I think it was in Tralee, however, where the Free State official happened to be an architect and surveyor, that a detailed inspection was attempted; broken window-panes, nail-holes in the wall, etc., were counted. At length, when the day was far spent and the work about 1% over, the architect threw in his hand and remarked, "Here, give me the b—y papers and I will sign the lot." I was not present, so this may be a yarn. This I do know, however, that it was only at the Curragh and in Dublin where any really efficient engineer organisation seemed to exist to take over the properties. There was no talk of values. A valuation would have been most difficult. My impression was that the Free State Government was prepared to do almost anything in order to get rid of us and get hold of the property.

When the evacuation was being arranged in the first instance, the C.E. of the Free State Army was one Roderick O'Connor, familiarly known as "Rory." He was, I believe, brought up as an engineer of sorts, but I imagine that, for a long time, he had lived on his political activities. He came to see me in his capacity of Irish C.E., and I must say the meeting in my office at G.H.Q. had its humorous side. Mr. O'Connor agreed with everything I said or proposed to do. He displayed great lack of any professional attainments whatever. What interested me most was the man, however. I had been connected with Ireland all my life, but I had never met his type before. He was a fanatical mystic if ever there was one. He sat before me and gazed at me out of a pair of deep dark brown eyes, and hardly seemed to realise that he was in

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the world. He looked miserably ill—I believe he was dying of consumption. However, he lived to be executed by his own people later on. I was told that he left the Free State army and joined the Republicans on account of some disagreement with Michael Collins over appointments. Be that as it may, the fact remains that he shut himself and a force of Republicans up in the Four Courts, and was directly responsible by his action for their destruction, and with them, for the destruction of most of the historical records of Ireland. As I said before, the Free State Government eventually executed him as a rebel. It is rather curious to contemplate how so many of the leaders of this Irish Rebellion perished at the hands of their own people. In my position I had little to do with these sort of people, and I can only remember seeing Collins and Griffiths once. They were at the time walking together in Duke Street, Dublin.

I have been speaking above of our relaxations during this time, and quite forgot the racing and hunting. Personally I did not hunt, I had not much time; but some used to, and at the Curragh they all did. Apparently anyone could go to a race meeting with impunity. We used to attend the Phœnix Park meetings, and I also went to Punchestown, and spent two nights in a country house in order to do so. Nobody molested me. At the races all the military teams from the Curragh, carrying Sergeants' messes, etc., were there as in old times, and, in fact, one would have thought there was no war. In point of fact, the Irish knew that if anything had happened there would have been no more racing, and they loved racing even more than they loved the other thing.

After the truce I went to Punchestown again in 1922. It was a curious sight to see no police, but yet to find the traffic being marshalled carefully enough. In old days it took a lot of Dublin Metropolitan Police to clear the course. This day there were no police and yet the course seemed to clear itself! The only untoward incident was that some sportsman—I think he really was a sportsman—stole the Lord Lieutenant's motor car. I believe it never was recovered either. It was a foolish jest, but very cleverly executed.

The rebellion went merrily on with its tale of tragedy, until July, 1921, when we were all electrified to hear that a truce had been proclaimed. It was received with rather mixed feelings, I think, but anyhow we were all released from our prison houses, our wives came over and joined us, and we felt a bit safer. My wife and I lived in an hotel opposite the Kildare Street Club, and I started a series of tours round the more isolated parts of the country. The longest was a trip to Athlone, and thence by car via Ballinasloe to Galway, a long, dreadful journey, nothing to see but a squalid derelict country. Starting by car from Athlone we journeyed via Ballinasloe (where the "Royals" were in miserable billets) and Athenry to Galway. Here we stayed two nights and visited the 17th Lancers

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(very poorly housed), and a battalion of the Worcesters. Our next day's journey was to Claremorris, where the Argyll and Sutherland Highlanders were quartered. They had a tin hut cantonment and electric light, run by a sapper of 59th Company R.E., I think, all fairly comfortable. Next day we went to Castlebar, where we found the Border Regiment in the barracks and quite comfortable. Thence we fared across a desolate bog country to Swinford, where there was a company of the A. and S. Highlanders, very badly housed, but thoroughly happy! The subaltern in command seemed to be enjoying himself shooting (it was in September). Then on again over the same ghastly country to Boyle, where there was a barracks, but I have forgotten by whom it was occupied. I can remember that the M.O. was much exercised as to the foulness (technical) of the water, but they all seemed pretty bobbish in spite of it. After this we went on to Carrick-on-Shannon. This was a horrid spot, and we met a new regiment just moving in to a perfectly horrible old jail, which had not been occupied previously. It was pouring with rain and the place was a sea of mud. I could only order that everything must be done to make things reasonably habitable, and push on to Longford, where we spent the night in the Longford Arms, quite a fair hotel. The landlady, I think, was not very pleased to see us. We had had a long tiring day. Next day we went on to Mullingar, where there was an infantry battalion in barracks. Here our motor journey ended and we took train for Dublin.

The next tour was by car from Dublin to Dundalk and thence all over the Monaghan salient, visiting such places as Monaghan, Ballybay, Cootehill (workhouse), Cavan (barracks), Virginia, Baillieborough, Kings Court, Carrickmacross. The Monaghan "salient" is the projection of the County Monaghan into Ulster. It was consequently a troublous part of the country. The troops in the area were poorly housed in all sorts of ramshackle places, though from a *war* point of view the billets were good.

A word must be said as to how we ran the works in these out-of-the-way places. The D.O.R.E. had a very wide area to cover, and we usually kept a sapper or two to do what was possible in particular places. The inhabitants did not mind working for us, in fact they would do most things for money, but their work was indifferent and expensive.

The astonishing part of it all was the unfailing cheerfulness that the troops all displayed. The private soldier of the British Army is certainly the most marvellous individual. His placidity and cheerfulness, his discipline and steadfastness under the most adverse conditions being simply astonishing. I have seen the men on duty in the streets of Dublin at the barricades quietly playing with the gutter children who, as often as not, were simply little spies, out to

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pick up what information they could get. The men seemed not to realise this and just treated them as children. I came back from the war with an unbounded faith in the virtues of the British soldier, and what I saw in Ireland even more firmly fixed that faith in my mind.

Ulster was a much easier proposition to tackle from my point of view than the Centre and South, as one could go about freely in uniform without an escort, in fact, an officer in a red hat was usually received with cheers and the waving of Union Jacks. The work was troublesome enough, as the troops were crowded and uncomfortable. Our worst job up there was, however, the Ballykinlar Prison, or rather, "Internment" Camp. The Camp was a hutment made during the War to accommodate four Battalions of Infantry. It was lighted by electricity, the huts were good and it was really very confortable. The internees were, however, a constant source of trouble. They were not pleased to be there, which is not surprising. They were dirty, idle and destructive, and made trouble whenever they could. One of their amusements was to try to tunnel out and escape, but we were able to prevent this, though it was a near thing once or twice. They certainly were a curious looking lot, some peaceful looking traders, some regular "wild men," some priests even. I would not have had the job of commandant for a lot. We had other places of confinement besides Ballykinlar, though that was the largest; notably Dublin, the Curragh (hut camp), Maryborough (old prison) and Bere Island. The latter was hard to escape from on account of its geographical position. It lay in the mouth of Bantry Bay, where they keep about the worst weather in Europe.

On my return from these tours, which gave me some real idea of the country, I settled down in Dublin and was busied with the arrangements for evacuation and redistribution of the garrison, a large proportion of which went to Ulster. Meanwhile the Free State Government and the Republicans had come to loggerheads. The latter began seizing important buildings in Dublin to form "*points d'appui*" for further operations. The Free State troops occupied such buildings as their side valued. The Republicans' first seizure was the Masonic Hall, a substantial building with a narrow street frontage, and of small military importance, except that it was near the entrance to Leinster House, where the Free State Government was functioning. Another theory was that the Masonic Order was hated of the rebels. Heaven only knows the true reason. Anyhow they turned the place into a pigsty, and drank all the liquor before they were persuaded to evacuate.

The next seizure was the Kildare Street Club. This was the stronghold of the Loyal Party, and this, added to the fact that it was a corner site and a solid house, makes the seizure understandable.

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I believe protection had been asked for from and refused by the Free State authorities, as some action against the Club was anticipated. At the same time I can't help thinking that the seizure could have been prevented if suitable steps had been taken, even without the assistance of the Free State troops. That, however, is but idle speculation. What actually happened was this. About 9 p.m. one evening I was sitting with some half-dozen others in the hall of the club, when a white-faced waiter appeared and said "They have come." I asked "Who?" and he replied, "The I.R.A." (he pronounced it the "I.R.Ah."). I went towards the door to see what was up, and was met by a gentleman with a revolver who told me not to approach. I should say that as the "Truce" was in being we were all unarmed. Eventually about 10 or 15 young men came in and held us up with "guns" and searched our pockets for arms. Finding none, they allowed those who lived out of the club to go home, and told those who were living in the club to go to bed! I got out as soon as I could and returned to the hotel opposite, where I was living. I, however, sent a subaltern off to telephone from a private house to G.H.Q. to tell the news, as I was afraid my hotel telephone might be watched. I found my wife in bed, and had half undressed myself, when there was a thunderous thumping on the door of our room. I went to see who was there and was confronted by a rather truculent Free State soldier, armed to the teeth, who demanded immediate admission. I asked him "Why?" and he said they were going to man the hotel windows in order to "shoot up" the Republicans in the Club opposite. I explained that he could not come into the room as there was a lady in bed in it, but that, if he would go away I would remove the lady, and he could then come in. He was an unusually modest youth for one of his sort and expressed extreme contrition at his apparent rudeness and vanished! Meanwhile I need hardly say my wife was dressed and ready to go a journey of any length. I got her into a back room and then went down to see what was happening. I found the street full of Free State soldiers, with lorries and machine guns and the Lord knows what else. I interviewed the officer in charge, told him who I was, and asked what his scheme was. He replied that he was going to attack the Club, but that "he could not start the bloodshed." Rather paradoxical I thought, but as he was full of zeal I said no more. I stayed up until 2 a.m. to see what was going to happen, and then they all packed up and departed, saying that the rebels had promised to evacuate the club at 8 a.m. next, or rather, that morning. It was a rotten show. I was perished with cold, as I was clad only in a dressing gown and pyjamas, with my stockingless feet thrust into a pair of slippers. Fortunately the hotel manager kept the bar open all the time. Whether for me or for the Irish Troops I don't know; anyhow, he saved my life. We then all turned in and slept.

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The rebels opposite I fancy slept too, as there was no more noise. Next morning, when I came down to breakfast, I saw the club windows barricaded and apparently all arrangements had been made for a prolonged occupation. My wife and I, however, evacuated our quarters in the hotel opposite the club forthwith, and went to live at another hotel near Kingstown.

The strife between the contending Irish parties increased in vigour as time went on. The Republicans next seized the Four Courts and garrisoned it, and it soon became a question as to who was going to rule the country. In the provinces the same troubles were taking place and the papers were full of shootings and burnings. The Free State Government seemed to be afraid to act, some said indeed that there was a good deal of fraternisation going on in a quiet way between the parties, who, though opposed to each other politically, did not really want to kill each other. However, eventually the situation in Dublin became impossible, and the Free State Government decided to evict Rory O'Connor and his men from the Four Courts.

The place had been in a state of siege for some time, but now a definite attack was decided upon. To carry this out the Free State Army borrowed some 18-pr. guns from us. The first news we had of impending action was an order for all officers living out to be ready to return to barracks. This was on a Sunday morning. On Sunday afternoon the order was cancelled. On Monday morning I went in by train to Dublin, and on arriving at Westland Row Station I heard that the battle had begun and that the quays were closed. I got on an outside car and told the man to drive to G.H.Q. He took me a long (and expensive) drive via O'Connell Street and the North Circular Road. On the way we came across the remains of a battle near the Parnell Monument, and a kindly spectator told me that it would recommence after breakfast, so presumably the combatants had broken off the engagement to have a meal. There were no dead men to be seen, and, as far as I remember, there were no casualties, but the street was in a fine mess with broken glass, etc. We arrived at G.H.Q. safely, and there I found an order to say that I was to be safe in barracks by 6 p.m. that night. A nice kettle of fish. The town was in an uproar, the bombardment of the Four Courts having commenced. Hume, my deputy, was similarly situated. His wife and daughter were living in Mount Street. We arranged that we should each take half the day off to arrange for the safety of the ladies. I got on an outside car at once and drove back to Westland Row. I had a lively drive, as my journey took me not far from the guns in action against the Four Courts. We got through all right and I got to Kingstown, collected my kit, told my wife to pack and to be ready to move at short notice, and got back to the office by 2 p.m., thus leaving the afternoon for Hume. He got back late at night, but

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safely. I was due to go to Cork that week, so I arranged to see my wife across the Channel on my way. The destroyer service to Cork had ceased, so one had to go via Holyhead and Fishguard, that is by the ordinary mail steamers. We were not allowed to go direct by train. I had to go out to Kingstown by armoured car. The town was deserted, shops shut, etc., in fact it was like a dead city. We were not fired at and got through safely. I met my wife at the boat and got her to England, then I went off via Shrewsbury and Cardiff to Fishguard.

On arrival at Cork I took ship in a destroyer for Berehaven. It was quite an amusing trip. On the way down we called at Castlehaven to put ashore a military officer on leave, who had been stuck up by the railways stopping. Castlehaven is a small but beautiful inlet, and, as we poked our way in, I noticed a lot of men on the hills round. On inspecting them through a glass I noticed they were all armed. I was just in time, as the unarmed boat was leaving for the shore. On hearing my story, however, the skipper armed his men. As the boat approached the shore all the watchers disappeared, and we heard afterwards that they had cleared out of the neighbourhood entirely!

The visit to Berehaven was an uneventful routine visit. I thought it was a desperate spot. I stayed two days and left in a destroyer about 10 p.m. on the second day. It was quite calm when we started, and we had been having quite an amusing evening before we sailed playing some game that sticks in my memory as having been rather like pitch and toss; anyhow I won. On getting outside, however, we encountered one of the worst gales of the year. Never have I had such a tossing. I had the skipper's cabin, but there were four inches of water washing about its floor. Fortunately the sea has no terrors for me and I managed some sleep. We were twelve hours on the journey, and, on arrival at Queenstown about 10 a.m. when I got on deck, I don't think I have ever seen such a draggled crowd as were my companions. A destroyer is something of an acrobat in bad weather, there is no doubt about it. The first news we got that morning was that the Four Courts had fallen. The garrison set it on fire and blew it up, and largely escaped in the smother, including, I believe, my friend Rory O'Connor. I had an uneventful journey back again via Fishguard and Holyhead, and found Dublin beginning to come to life, though it looked a wreck. The Four Courts gone and most of O'Connell Street was in ashes.

Although technically quiet I think the town was more noisy, especially at night, than while the Rebellion was going on. During that period we were able to keep the rebels fairly quiet, but, when the two Irish parties started squabbling and shooting at each other, nothing seemed to keep them quiet. I often thought they must be firing in the air to hearten themselves and depress their opponents;

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their acknowledged casualties were, anyhow, insignificant. Once a party of them formed up in the Cattle Market and began to shoot at the R.A. Officers' Mess across the street, but were dispersed by one ill-directed round from the British sentry. My wife was living at this time in a house a few doors away also facing the Cattle Market, in the North Circular Road, and I was away in Ulster. I may say that ladies had been allowed to return by this time and were able to stop on until the evacuation, if they cared to face the risk. There certainly was a risk of being shot by some irresponsible patrol all the time, but the risk was the same for all the people living in the city, no matter who they were.

There were, of course, innumerable incidents. The first one that I actually saw was the funeral of a Brigadier who had been ambushed in Kerry. The procession started at the Military Hospital near G.H.Q. and proceeded via the quays to the Northwall, where the ship was lying. The funeral was attended by the troops, and the C. in C. and all his staff, as well as by an enormous number of Dublin people. The latter were most respectful; those who were not, I fancy, had their hats knocked into the river. We accompanied the procession some way down the quays and there was no sign of a hostile demonstration.

Another case, which shows I think the attitude of the Dublin citizen generally at that time. During the fighting time, before the truce, in fact just after I first arrived, I wanted to lay in a stock of liquid refreshment. My brother-in-law told me he would bring me to a merchant whose stock was unquestionable. I walked down the town and lunched with my brother-in-law, and en route passed a restaurant called the Dolphin Hotel. Everything was quiet and peaceful. After lunch we heard that two policemen had been murdered in front of the Dolphin at about the time I was passing. Later on, at the wine merchant's, we were discussing the incident, and he said he was there when it happened. I asked, "What did you do?" He replied, "I bolted by the back door, as it was no place for me!"

To cite another case. An Infantry patrol under a young subaltern was moving down Brunswick Street one night. They were fired at, and the young officer let off all the rounds in his revolver. He then saw a "Shinner" advancing on him pointing a revolver at him. It was an uncomfortable situation for the subaltern, who had no time to load. However, he did not hesitate. He first hurled the empty revolver and then dashed at the "Shinner," collared him low, bumped him on the ground and sat on his chest before he could fire. The "Shinner" said to him, "You had better shoot me now you have got me," but the boy replied, "No, I am going to have you hanged." I believe he was, too, and that in a very short time.

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Another case. There was an *abbatoir* in the North Circular Road, where the Army rations were drawn. An armoured car and a lorry went to draw the rations one day about noon. They were rather careless as regards keeping a look-out while the lorry was being loaded. A man dressed as a British officer came into the yard and shot the lot, and then decamped with the armoured car. It was a daring thing to do, but, as the man was credibly reported to have once been an officer in an Irish regiment and was wearing his old uniform, it was a dastardly one.

We lost one Sapper officer only during my time, and that was near the end. He was kidnapped in Cork and his body was subsequently found, but we could never find out what actually happened. All that was known was that he had gone down to the Cork Club to dine (it was after the Truce) and he was never seen again alive.

A few words must be said as to the R.E. organisation. There were seven C.R.E.'s Districts. They were as follows:—Dublin, Curragh, Cork, Fermoy, Limerick, Athlone, Belfast; later on, after Cork was evacuated and the garrison of Ulster increased, there was one at Omagh. These C.R.E's. had their D.O's. all over the country with assistant D.O's. The D.O's. really did the work, as the C.R.E.'s had great difficulty in getting about, though they did a wonderful lot of travelling. The labour employed was mostly civilian, either by contract or direct. The Military forces were organised in four Divisions with Headquarters at Dublin (Dublin District), Curragh (5th Division), Cork (6th Division), Belfast (1st Division). Dublin District had a Works company of R.E., 5th and 6th Divisions had each two Field Companies. The 17th and 59th were in the 5th Division. The 17th Company was concentrated as a reserve at the Curragh. The 59th was scattered in detachments all over the West. The 12th and 38th Companies were in the 6th Division, 38th Company concentrated at Fermoy, 12th Company at Limerick, with detachments all over Clare and Kerry. In the 1st Division there were no Field units. We had only a Works company at Belfast.

Besides the above we had Searchlight units, with sections scattered all over the country. These people had a very entertaining time, or at least they said so. They were equipped with motor lorries on which searchlights were mounted, and their job was to accompany and assist raiding parties and patrols at night. The fitting and equipment of the lorries was an unending source of argument, as was also the method of armouring them. The difficulty about the armouring was to make it efficient, and yet at the same time to allow the lights to shine, and further, not to make the lorry too heavy to move. Anyhow, they did very good work, and, as I said above, seemed to enjoy themselves.

The great difficulty about the R.E. Services was that the peace routine as laid down was not suitable to the exigencies of the

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case. I found the best way was to try to have a major at the headquarters of each brigade and to call him a Deputy C.R.E., and give him a C.R.E.'s powers without his staff. The real C.R.E. had to do all the accountancy. I could not run to a major everywhere, but I found that the rank did not matter, as long as the individual was a " live " man. In my office in Dublin one was pretty helpless really. All one could do was to try to help by giving power to the people who had to do the work. One method of help which had been very carefully organised by my predecessor, Brig. General Baker Brown, was to have a good drawing office. Here we kept a lot of stock designs as to how to utilise huts for various purposes, and I believe it saved a lot of trouble to some people. On the other hand, there are always folk who will never accept anything but their own ideas. I think we got on pretty well, and the authorities were surprised that I was so cheap! The secret was to get the best man possible into a job and to trust him absolutely. On the other hand, a weak man must be scrapped at once.

At last the end came. In the autumn of 1922, rumours of evacuation were abroad, but we still had to go on with our preparations for the winter housing of the troops evacuated from the Centre, South and West of Ireland. It was a big and by no means a cheap job. However, at last we heard the decision that we were to leave at the end of December. The moves were extraordinarily well and quietly carried out. My principal anxiety was how to deal with the civil subordinates who had served me so loyally. To leave them behind was unthinkable, and yet there were difficulties. However, eventually I think I was able to provide for all those who desired to leave, either by posting to Ulster or England. Some took service under the Free State, and I don't know what was their ultimate fate. I sold the old mahogany bookcases in the C.E.'s office, sent the best of the contents to London, and the old clock, that had been there for 100 years, to the Chatham Mess. The office closed on 16th December, 1922, and we all went to England. A closing down office under my deputy, Colonel A. H. B. Hume, opened immediately at Hounslow to finish off, and they functioned there until April, 1923. Personally, I was put on half-pay; so ended my experience of Ireland. My family have lived there for 250 years, but I don't think I could ever go back. Those two years, 1921-22, were, I think, the worst I ever experienced during my service. It was a horrible experience. It was not so much the possible dangers, as the uncertainty as to who were friends and who were enemies. As you walked the streets, you had to assume that everyone was an enemy, that was the only safe way. To have to do that with people who spoke your own language was horrible.

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PIONEER MOTOR-CYCLING IN INDIA.

By Lieut.-Colonel E. W. C. Sandes, d.s.o., m.c., R.E.

When one sees the modern motor-cycle, with its efficient engine, 3 speed gear, chain drive, kick starter, spring forks, footboards and handlebar control, it is difficult to realize that 24 years ago motor-cycles were objects of wonder and often of derision, and that their riders mounted them in a state of pleasing uncertainty as to what would happen, and could never rely on getting anywhere, even if they had the luck to be able to start. Still less could they hope to complete a run of 30 miles in India without at least two or three minor breakdowns. Yet this very uncertainty was half the charm of the ride. The roar of the engine, when it did consent to run, was sweet music to the rider's ears, and the pride and satisfaction which he felt when he had actually got home again—with dirty hands and nicely oiled trousers—more than compensated for the trials of the journey.

It was at Chatham in 1901 that I first saw a motor-bike. It was a 2 H.P. Singer with a steel-disc rear wheel within which reposed the motor—a surprising arrangement which abolished all chance of air cooling and brought about 4/5ths of the combined weight of the rider and machine on to that wheel, so that it skidded alarmingly on grease, while the front wheel bounced gaily in the air. Still the Singer got along quite fast when it overcame its reluctance to start, and it was at least a novelty. The remembrance of this freak induced me to try my luck with a motor-bike in India, so in January, 1903, I placed an order for one with the only Bombay firm which could supply them, and it reached me at Wellington in the Nilgiri Hills in Southern India in February, 1903.

The correspondence with the firm was long and wearisome. The price of my 3 H.P. Quadrant in Bombay was Rs. 1200/- (about £80), so that its cost was not far short of £100 when it reached me at Wellington. The firm wanted to know my height and weight, in order to suggest *a suitable height of frame and a safe horsepower!* They recommended 2 H.P. for riders of medium weight, but could supply a 3 H.P. machine for those who were not afraid of such a monster. As the country around Wellington is mountainous, and the cantonment is 6,100 feet above sea level, I decided to risk the terrors of 3 H.P. and ordered the larger machine.

In due course the case arrived by train and bullock cart, and willing helpers assisted me in unpacking the machine and attaching pedals,

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saddle, lamp and other fittings. No one in Wellington knew anything about motor-bikes, so we sat down to discuss the rather vague instructions, and to trace out the electric circuits of the accumulator ignition system. We pumped up the tyres with the small hand pump attached to the top tube, filled up with petrol and lubricating oil, tested the accumulator—which gave a good voltage in spite of loss of acid on the journey—and then gazed in wonder at the machine which shone like a jewel in its new aluminium enamel and nickel plating. Perhaps the photographic illustration will help the reader to follow my description of it.

The frame of the 3 H.P. Quadrant was built almost on the lines of that of a "push-bike," but with rather heavier tubing. There were no spring or girder forks, no carrier, no clutch or gears, and no footboards or even footrests. The tyres were 2" Dunlops. Clipped into the frame were two tanks. The large one, in front of the saddle pillar tube, was divided into two compartments by a vertical partition, the front compartment containing the petrol and the surface carburettor, while the rear compartment held the accumulator and induction coil. The small triangular tank, behind the vertical tube, held lubricating oil, and, attached to the tube itself was a plunger pump to force oil down into the crank case, a drip feed system being unknown in those days. It required some practice to oil the motor while running, as one had to work the plunger, under and behind one's right leg, while leaning over to the right to see if oil was really being sucked into the glass cylinder of the pump with each stroke, and meanwhile to avoid stray Indians, bullock carts and dogs. The plunger had to be worked every 8 to 10 miles. There was, of course, no oil gauge on the crank case, and the rider pumped till smoke issued from the little apology for a silencer considerately placed between his knees and below the petrol tank. By experience I soon learnt that the silencer got almost red hot after a few miles running in India, and needed frequent observation—but of that more anon. Also its connections with the exhaust pipe and the tank were elementary, and more than once the nuts loosened under vibration and it fell off. For the same reason other fittings dropped off from time to time, and many were lost, so I kept a large assortment of spares.

Spray carburettors were almost unknown on motor-cycles at the end of 1902, and the few that had appeared were unreliable in the extreme. The Quadrant had what was called a " surface carburettor," i.e., a tray or compartment inside the petrol tank from which, I believe, wicks led into the petrol below, and in which petrol vapour was allowed to mix with air to form an explosive gas. A simple, though primitive, arrangement, which had the advantage of reliability, and was not affected by water or dust in the petrol. The petrol tank was well made of sheet brass and did not leak. In 1903

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most tanks leaked after a time, so the rider carried a piece of soap which served the double purpose of temporary repairs to the tank and frequent washing of dirty hands. The filler cap was only $\frac{3}{4}$" in diameter, so replenishing the tank was a long job.

On top of the tank was a transverse tube in which was a gauze-covered orifice to admit air to the surface carburettor, the orifice being uncovered as much as desired by working a small lever on the tube. Another lever on the tank was the combined ignition and throttle control, and, when pushed forward, it also connected up the low tension circuit. In addition there was a small break in this circuit, as a safety device, which was filled by a flat piece of metal before starting. Of course, this slip of brass always got lost, and a supply of 4 anna pieces was advisable for replacements. Thus it will be seen that all control of the ignition and mixture had to be done by operating the two levers on top of the tank, and consequently with only one hand on the handlebar. The results of the action of the surface carburettor were most exciting. The rougher the road, the more the petrol was shaken up, and the stronger the mixture. Consequently the machine often increased its speed without warning and the throttle had to be closed hurriedly. If one was turning a corner and struck a rut in the road, the acrobatic feat of making the turn with only one hand on the handlebar, while throttling down with the other, was often worthy of a circus. Many a time I only missed the ditch by inches.

In the rear compartment of the tank the upper part held the induction coil—of non-trembler variety—and the lower part the accumulator, the compartment having a door so that both coil and accumulator could be exposed. The accumulator was an endless source of trouble. As the machine weighed less than 150 lbs., and had only 2" tyres and no spring forks, the vibration on Indian roads was terrible. The rider's wrists were often quite numb after a 20 mile spin. The acid spilled from the accumulator, and, after a time, ate through the floor of the tank, while the accumulator itself split and leaked and the plates buckled and sulphated. Early in 1903 at Wellington, and later in that year at Secunderabad in the plains, I found that there was no electric installation of any sort from which to charge an accumulator. I thought of getting a set of primary batteries for charging, but the Bombay motor firm advised me to send accumulators to them for charging (400 miles away) and undertook to return them, when charged, filled with distilled water instead of acid so that I could refill with acid when they arrived. The result was a complete failure. I then designed a special box for sending an acid-filled accumulator by rail. It was on the lines of a binnacle compass with concentric rings transversely pivotted within it, so that the accumulator, slung in a receptacle inside the innermost ring, remained upright whatever happened to

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the box. Incidentally my design was patented or protected by someone in England a year later, and he described his design as "novel." The box prevented any acid from being spilled, but I found that the heat of the journey ruined the accumulators. In despair I resorted to dry batteries, trying Hellesen batteries at first, and later a battery of 3 "Transport" cells, which were filled with a solution of sal-ammoniac. These cells lasted for several months. To avoid vibration I hung them at the back of the saddle in place of the tool bag and put the latter on the handlebar.

The Quadrant engine was a single cylinder with side-by-side poppet valves. It was fairly well balanced, and at most speeds up to 25 miles an hour there was little vibration from the engine. The steel of the cylinder was soft compared with modern steel. After about 5,000 miles running the cylinder wore slighly oval, and two or three sets of piston rings had been used by then, but this was probably due partly to defective lubrication. Some play developed in time in the connecting rod bearing within the piston, so that vibration became considerable after about a year. The valves, especially the exhaust valve, pitted continually, and had to be ground in every month or so. When it became necessary to dismantle the timing gear the re-timing was a problem to a novice, as there were no marks on the pinions. Nevertheless, considering the limited experience available at that time in the design of motors, the engine was a creditable production, but the frame of the motor-bike was not stiff enough to carry it and gradually developed a lateral twist, so that the front wheel was never quite vertical.

As far as I can remember, the machine could be jacked up on two separate legs which pivotted on the rear axle. The rider sat on an ordinary bicycle saddle, and kept his feet (if he could) on the pedals, by means of which he helped the motor on steep hills. Pedalling was hard work as the gear was low, but the pedal gear was useful when one broke down hopelessly 5 miles or so from home. Many a time did I remove the belt and pedal home. On the level it was possible to get along at 10 miles an hour, though the smallest hill meant dismounting and pushing.

The leather driving belt was of triangular cross section, which was a novelty in 1903. This shape was considered to be a great advance on the flat belt of previous years, though some riders still preferrred the flat belt. The worst feature of the triangular belt was its fastener, which was merely a piece of steel wire shaped like a C. As no belt punch had been invented, the rider had to bore holes with a gimlet through the ends of the belt and force the curved ends of the fastener through them. Late in 1903, hinged fasteners, with screws to pierce the belt, appeared on the market. Lubricating oil always leaked from the big end bearing on the belt pulley side, and the pulley picked up this oil and transferred it to the driving belt, which

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sprayed any excess of oil on to the rider's left trouser. The oil which the belt thought fit to retain caused it to slip, and gave it a hard and polished surface of incredible filthiness in spite of frequent scraping. Because of this slipping the belt pulley lost its V section through friction, and the belt slipped still more. It was necessary, therefore, to keep the belt very tight, and this tension was too much for the fastener, which tore through its holes. One got quite used to the occasional roar of the racing engine when the belt had been left behind in the dust. Collan oil, or castor oil, was recommended by the makers to keep the belt pliable, but, in practice, the lubricating oil from the engine made the belt as pliable as anyone could want—and also destroyed it. I always carried a couple of very short lengths of spare belt to insert as the original belt was gradually cut down shorter and shorter. The grimy operations on the black and oily belt spoiled many a ride, but the clean and efficient rubber belt had not then made its appearance in India.

A novel feature in the 1903 Quadrant was the forward extension of the front mudguard over the front wheel. Both mudguards were very narrow, and on muddy roads the rider's legs were soon well coated with dirt, but the extension of the front mudguard saved his face from a similar coating, and the makers were proud of the luxury thus given. A leather flap at the bottom of the front mudguard was also a novelty designed to protect the engine and the rider's feet.

I covered about 5,500 miles on the 3 H.P. Quadrant between February, 1903 and August, 1904. In April, 1903, when it was in good condition, it carried me from Wellington up to Ootacamund, 7,300 feet above sea level, which included a climb of about 1,500 feet. It did this without much pedal assistance, and was almost the first, if not the first, motor-bike to reach Ootacamund. The return journey, with very inadequate brakes, was exciting. The machine had ordinary cycle brakes on both wheels, one operated by hand from the handlebar, and the other, I believe, a back-pedalling brake. The engine, however made a good enough brake, except in emergencies. The Indians in Ootacamund lined the roads to see the Quadrant rattle past, and shouted " Chota Shaitan Gharry " (little Devil carriage) and " Chota Ag Gharry " (little Fire carriage), the former seeming to be the favourite name, though not too flattering to the rider. The machine was swallowed up at once in a crowd if I stopped and left it for a minute, and eager hands tried the fittings to see if any were loose enough to be removed unseen. As nothing faster than a dogcart or a bicycle had appeared on the roads, the traffic made no attempt to move quickly to one side, however loudly I sounded my cycle bell, which was the predecessor of the horn, and, of course, no driver or foot passenger knew the rules of the road. In Secunderabad, when I arrived in July 1903, I believe that there was one motor

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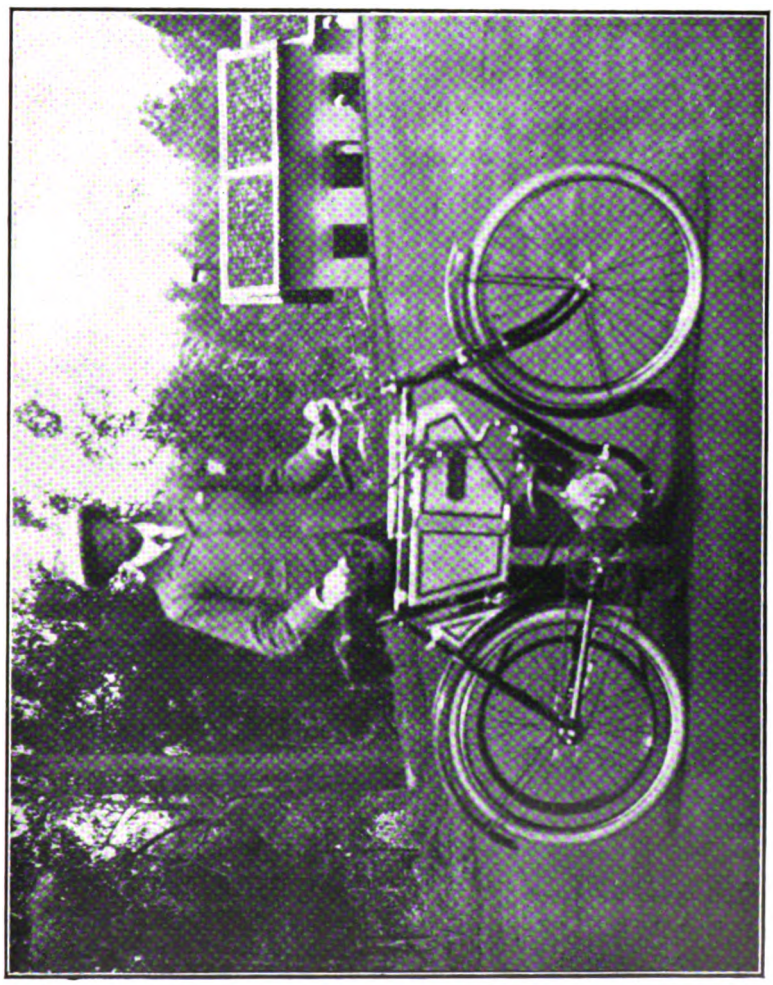

The 3 H.P. Quadrant of 1903.

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car, though I never saw it, but soon afterwards a major in the Lincolnshire Regiment produced a motor-bike with a flat belt drive. When I left the place in August, 1904, there were three other motor-bikes besides my own, and two other cars. Up till then no motor vehicles were registered or numbered, and there were no taxes. I think that number plates appeared in 1905, but taxation of privately owned motors was not introduced anywhere in India till some years later, and even now it is not universal. Speed was limited in 1903 by the small power and the unreliability of the engine, and I never heard of a complaint of dangerous driving. The motor-cyclist himself was in continual danger from dogs and cattle. Native dogs would charge out in a pack from every village and surround the machine, so, after two or three nasty falls, I carried a canvas bag full of stones on my handlebar and opened fire as the pack neared me. A cutting whip, clipped to the front forks when not in use, was then brought into play to beat off the brutes on either side. Cattle seemed to have an intense aversion to the noise of the "Pulputtia," as the motor-bike is now called in some parts of India. If a herd was passed near the road, one or two of the younger beasts were almost certain to snort and charge. When the road ahead was clear it was usually possible to accelerate enough to outpace the cattle galloping behind, but I was sometimes held up for ten minutes or more by a brute who blocked the way and, when I had dismounted, circled round me looking for a favourable opening.

The old Quadrant was very noisy, so I naturally wanted to silence the engine more effectively. Knowing nothing of back pressure, and not realising the heat transmitted to the silencer itself, I made a thick canvas bag and tied it over the silencer, which, as I have said, was immediately below the petrol tank. A sorry confession to make, but there it is! The result, from the point of view of silencing, was all that could be desired, and a muffled purr replaced the rattling bark of the explosions. After running five miles, however, I thought I smelt something burning, and concluded that my trousers must have touched the cylinder—a not uncommon occurrence. But, on looking down, I saw to my horror that the bag containing the silencer was rapidly blackening on one side, so I applied both brakes and jumped off. As I stopped the bag burst into flame, and the flames ran up each side of the petrol tank. There was nothing for it but to try to beat them out with my cap before the tank exploded, and luckily I managed to do this. The lesson was not wasted. I abandoned my amateur attempts at more efficient silencing.

Motors were very expensive to run in 1903 in either Wellington or Secunderabad, because no petrol could be bought locally. It had to be ordered from Bombay in 4-gallon drums, which rarely held more than three gallons on arrival, and it was classed by the railway companies as a mild form of "explosive," and charged for

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accordingly. As far as I can remember the cost on arrival worked out at about Rs. 5/- (6s. 8d.) a gallon. Lubricating oil also had to be sent from Bombay.

An adventurous friend once suggested that he would like to be towed behind my motor-bike on his bicycle, so we got a length of 20 yards of rope and introduced a yard of stout rubber into the middle of it. He took a turn with one end round his handlebar and I tied the other end to my saddle pillar. For some miles we buzzed along merrily on the level till I got tired of looking round to see if he was still there. Then came a small descent down which I coasted with the exhaust valve lifted. When I switched on again at the bottom I was surprised to hear a tinkling sound mixed with the banging of the exhaust so I took a peep at the engine, but all seemed right so I opened the throttle. The tinkling increased and I looked behind me. In the distance on the road sat my gallant follower rubbing his head, while behind me on its side bounced the wreck of his bicycle with the towing rope firmly wound round its front wheel and hub. Coasting down the hill he had naturally gained on the motor-bike, whose engine could not be freed, and had run over the trailing rope which had jammed his front wheel. That was the end of *his* experiments in being towed by a rope! We afterwards tried the method of towing with the cyclist's hand on the motorist's shoulder and got along very well, though it was tiring to both riders after a few miles.

Since those early days I have had motor-bikes of many different types—a 3 H.P. Triumph in 1905, a 5 H.P. twin-cylinder Rex heavyweight in 1909, a 2½ H.P. twin-cylinder Moto-Reve lightweight in 1910, and lastly a 5 H.P. twin-cylinder Clyno heavyweight in 1913—but the memory of the old 1903 Quadrant is still fresh. I ran a trailer with the Triumph, a cane sidecar with the Rex, and a coachbuilt sidecar with the Clyno; yet, though these later machines were more powerful, reliable and speedy than the Quadrant, they did not give the excitement which made pioneer motoring what it was. The 1905 Triumph was an immense improvement, for it had girder spring forks, large tyres and saddle, rubber belt, handlebar control, footrests, and a spray carburettor, but even then accumulator ignition was recommended in India in preference to the magneto, which was still in the experimental stage, and was expected to deteriorate through loss of magnetism from road vibration. I risked magneto ignition on the Triumph and did not regret it. The old Quadrant was sold to a young Parsee doctor in Secunderabad in August, 1904, for Rs. 550/-. It was an extraordinary machine, but it could be guaranteed to teach its rider more about the inside of a motor in two months than a modern machine would in as many years. The experience was useful, though, like most experience, hardly bought.

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OUR LATER SELVES.

By "Arthur Vincent."

To a 'Wild East' reader visiting Home after an unusually long absence abroad the successive articles by Captain Kerrich and 'Praefectus Fabrum' and Sir Reginald Buckland's letter have at least this in common, that they are of extreme interest. It is certainly not surprising that somewhat different conceptions of our own ideals should exist within the Corps, when such widely divergent ideas of us are to be found in individuals of other arms and services. The not unfounded fable of the commander who used his Sappers as escort to his guns still lives; a distinguished commander quite lately told us that in his first command, during 1914-18, he did not know what on earth his Sappers were for, until battle brought revelation, after which he would go nowhere without them. On a wider basis, the writer has equally been told, and by high officers at that, that we are a fine Corps best given a pretty free hand, and that we should exist as departmental and entirely subordinate ancillaries to the 'Q' staff.

The original idea of this article was to repair an omission, and not necessarily to discriminate between the rival views of the two previous ones; although we confess straightway to an intuitive leaning towards 'Praefectus Fabrum' and his support of General Macdonogh. In its development, however, facts and reason diverted it steadily towards the latter. Nevertheless, both previous articles have made at any rate one reader think hard upon facets of our task which ought to have, but alas did not, occupy his attention earlier.

Returning to the charge, both articles reveal a notable omission which it is desired to try to fill constructively. Neither of them brings out the very marked task of the R.E. officer of more senior rank, constant alike in peace and war, which is the business of directing efficiently, and getting the very best out of, his subordinate specialists of various kinds. Speaking of India, even the C. R. E. of a second class District has at least one specialist, to wit his E. & M. officer; and amongst the others he may well find officers who have themselves acquired some specialist knowledge of any of the other branches of the daily work, such as building construction, water supply, sanitation or architecture. In war C.R.E's., and much more so those Sappers who hold still higher posts, will find around

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them, whether on their staff or within their command, a much larger number of specialists of whom many may be late civilians with little or no military knowledge. The harmonious and efficient co-ordination of the efforts of all these towards the common end calls strongly for particular qualities. Before these are examined, however, it is desirable both to show and to insist that the higher direction of military engineering in the field must remain in the hands of the regular personnel. Without that, the training of the Corps towards its higher duties might well become unnecessary.

In respect of the higher R.E. appointments, there seems no doubt that the first essential qualification is sound and instinctive military knowledge. From C.R.E.'s upwards, the engineers to-day are very close in the councils of Commanders and Staffs—if the latter are doing their job properly, that is! Tomorrow, on the analogy of 1914-8, the relationship will certainly not decrease. Senior Sappers must, therefore, without wasting time over a single unnecessary question, be able in conference to follow clearly and continually what is in the Commander's mind, what is in his Staff's mind, and how the Staff are working and will work to put his decisions into effect. That ability can only be achieved by lifelong professional knowledge of the military machine, supplemented by the study of military history in general and by that of military engineering in particular. Such knowledge is perforce denied to the best of civilian engineers, who naturally have put their own trade first and foremost all their lives. It is only by the habitual and automatic understanding of every relevant military detail, with nothing left in fog or strange terminology, that a military engineer can be fairly certain that his advice, given too in even consonance with the military means available and the military end aimed at, will be as sound as it needs to be. It thus seems unquestionable that the senior military engineers, particularly in the highly technicalized campaigns of nowadays, must be taken from the regular ranks alone. The same, in a lesser but still important degree, applies to their personal engineer staff officers; for a personal staff officer who has to learn a lot of his profession whilst he is the responsible first assistant to a responsible senior officer, is never going to come within thirty per cent. of true efficiency.

It is therefore the regular Sapper who has got to train and be trained for the higher duties of his Corps in war. How can he best aim at it? Passing now from the purely soldiering side of his training, which is the affair of the General Staff, his seniors and himself, it is necessary to look broadly at his engineering duties. Those given on page 470 of the *Journal* by 'Praefectus Fabrum' can be taken en bloc. Yet almost as a first duty, in the case of the higher ranks, there is for the senior Sapper the efficient co-ordination of the work of the experts under his orders. His no more than general

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knowledge of engineering in all its war branches is here taken for granted, as being the duty of every officer of the Corps; but his handling of the specialists can work greatly for good or evil. Take for instance the Chief Engineer of a good sized Army Corps on any front in the world, let alone the C.E's. of Armies and the E's-in-C. of other fronts. He is practically certain to enjoy the services of regular or non-regular specialists in E. and M. work, in light railways, in water supply, which east of Suez is practically always a vital matter, in building construction, in roads and bridges, and so on. If not actually posted to him as such, they will be found in the flesh in various R.E. appointments. How is he to get the best out of them.

We were once asked: "How much ought you to know about a specialist's trade in order to utilize him efficiently?" For want of an established reply, we answered: "Enough to know when he is talking sense." For the purposes of war, where needs and deeds are sharpest and where anything less than sense is apt, in front of the particular problem being faced, to be nonsense, the definition may perhaps be allowed to stand. Broadly, it crystallises down to a sound knowledge of general principles in all the main branches of engineering which a Sapper is likely to have to direct towards the ends of war, backed up with the practical knowledge that comes with all R.E. experience. To a 'Wild East' reader, that sound knowledge of general principles does seem to be precisely what is afforded by the present training of the R.E. subaltern.

Proceeding, that knowledge gives the full degree of 'intelligent understanding of the other man's job' which is the first basis of efficient co-operation. Next, it enables one to discern quickly whether or not the specialist's particular knowledge is, or is not, the required asset for the business in hand; and it also allows one to judge fairly how far the specialist may have a free hand as against the other considerations affecting the problem. It also guards against a common danger, that of the specialist's natural inclination to view things with an unduly specialist eye. As an illustration of this it is only necessary to recall the noble lord, largely interested in the automobile world, who was chaffed in the Upper House for looking at statesmen's problems through his motor goggles. Further, with a knowledge of general principles, it is difficult to fall into the error of not seeing the wood for the trees.

It is not the 'specialist in nothing' who is to be advocated, he represents the extreme case, and extremes are usually unsatisfactory. To be too much of a 'Jack of All Trades' in the Corps leads to indefiniteness of purpose, and thence to that type of 'drifting' which is all too likely to end early and irredeemably in a lieutenant-colonel's pension. Moreover it leads to temporary specialization and subsequent forgetfulness. It is quite possible to specialize quite satisfactorily in one or two forms of engineering without

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wearing the motor goggles quoted, and without failing in any way to keep up-to-date that wide knowledge of general principles which is essential to the control of varied experts.

No Sapper can hope to keep up-to-date in the technical progress of all the branches of engineering required in war, he must always be prepared to find the individual experts far ahead of him. Nevertheless he can, even in his spare time if his official work does not afford opportunity, keep very well up-to-date in general principles. It is just this latter knowledge, combined with the wealth of commonsense which is reaching out to be grasped in the everyday work and experience of every Sapper, which will give him the mental equipment necessary to get the very best out of the collective specialists.

From thence we pass to ask, "What is a first class engineer?" General Macdonogh used the term in respect of military engineers. In civil life the expression can fairly be said to embrace two types, firstly, the specialist at the head of his profession or near it, such as Senator Marconi; and secondly, the experienced engineer who controls and directs a large engineering firm containing numbers of varied specialists, such as may be met with in all the big commercial centres of the world. For military purposes, it seems very clear from the ground gone over that it is the second of these men who fulfils the definition. In his past he will almost always have practised specially some one branch of engineering, be it an ordinary Garrison Engineer's construction work or anything else; and the practical detail to which he has gone in this will enable him not to fall foul of detail in the other specialist trades he controls. Taking General Macdonogh's definition to apply to this second type, we ourselves would prefer to regard it as permanent, indeed as something nearer to an axiom than to a definition. It is to this end, we venture to say, that the bulk of the Corps should direct its efforts, in consonance with its early training; after due provision has been made for the number of definite specialists which it is likely to require in the regular cadre in war.

To exemplarize the test of this particular pudding by eating, we need only go back as far as 1914-8, when the standing of the Corps was greatly enhanced by the successes of its senior engineers. They were just of the type advocated, men fitted by long and often very general experience, by commonsense and by up-to-date general knowledge, to direct and control their numerous specialists towards the results which are known to all of us.

Before closing, we would dare to join issue with General Buckland upon one point. He quotes in his letter the Sapper who gets his *p.s.c.* as thereafter aspiring "to command something other than the R.E. of a Division, in fact, a Brigade of Infantry. . . ." As nothing but a personal opinion, we ourselves have held long and strong quite another point of view, namely, that a certain proportion of the R.E

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p.s.c's. should stay in the Corps, not by chance or mischance, but by design.

In older days, force of circumstances made this view barely tenable, very few vacancies fell to the Corps at Camberley and Quetta; and at that College which we knew intimately before the War, they fell frequently to men of outstanding personality who moved swiftly to high Army office almost as if by right. Since 1919 a much greater number of Sappers have passed through the Colleges; and even if by now their total has been much reduced, as notably at Quetta, there are still no less than eight at Camberley at the time of writing. Surely some, at any rate, could be made available for the Corps itself? The Infantry has a host of *p.s.c.* Battalion Commanders, for instance: it is commonly said in Indian messes that, in years to come, the *p.s.c.* will even become a necessary qualification for a battalion command.

Take the Army point of view. It seems an old-established principle that service on the Staff is a duty returnable after having the advantages of the Staff College course. On the other hand, at long long last the Colleges are becoming able to provide a little more than the immediately required graduates, so that there is room for a few elsewhere: for years of course we had no reserve of trained staff worth speaking about. At another angle, we had asked more than one senior commander: "Other things equal, would you rather your C.R.E. or C.E. was a *p.s.c.* man, or not?" In each case the reply was unequivocally affirmative.

Well, circumstances have made it temporarily much more possible than before for the *p.s.c.* Sapper to aim at the career of a *p.s.c.* Sapper; and it may be advocated as intrinsically good, so long as the opportunity exists. One of the first bases of the Staff College training is co-operation, and in this case it is built upon a far more than superficial knowledge of the other men's jobs. It has been pointed out that to-day the higher engineer officers are, as they must needs be, very close in the councils of Commanders and Staffs. The advantages which the Army would gain from the former's Staff College training are thus too obvious to need elaboration. The main question seems to be whether or not, in these days of recovery from war casualties and of cheeseparing finance, the Army can afford to pass through the Colleges officers not necessarily destined for the Staff. That is not for us to answer, but from a careful and not at all disinterested scrutiny of the necessary statistics, we do believe that one Sapper a year, or perhaps two in three years, could be advantageously so spared. In India, indeed, the C.R.E's. of Districts are officially shown in the Army List as "Attached to the General Staff," which is an additional and authoritative plea.

From the Corps point of view the advantages are plain. The closer co-operation possible would benefit alike the Army and the

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Corps, the military training of the Corps would be sure of a measure of gain, and graduates with their higher military training would not be lost to the engineering cadre of the corps as they so often have been in the past.

There remains to consider the outlook of the individual. His engineering experience must naturally suffer; but two years away from it is, after all, no more than the period which his grandfathers used to take from India on actual leave, and some of his contemporaries in civil employ and under civil leave rules take almost the same nowadays. Even if he takes one four-year staff appointment after graduating, as seems usually to be required of him, a gap of six years is not an irreparable one, if it is neither prolonged by leave nor added to by later intervals. Better still, the six years can be split up by a return to Corps duty after the College, for a year or two. It is believed that one year's return is now compulsory.

As an individual opinion, therefore, but one formed long ago and strengthened since, it seems that the career of a "*p.s.c.* Sapper" is one which needs more attention drawn to it as a very desirable asset for both Army and Corps. Better if we could kill, once for all, the old idea that the Colleges are necessarily but gates out of the Corps into a better land. Besides, there is no better land.

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MODERN PRACTICE IN E. AND M. ENGINEERING.

III.

NOTES ON PROTECTIVE GEAR.

By MAJOR A. C. FINNIMORE, M.C., R.E.

1. *The Necessity for Protection.*

Protective gear of some sort is well known to be necessary in every system of distribution of electrical power. The larger the system, and the higher the pressures employed, the greater is the need for adequate protection. In a study of the matter, the first question to consider is, what are the risks from which protection is to be sought? Then arise further questions, such as, how can such risks be avoided, what degree of security can be attained, what additional expense and complication must be involved in supplying the desired degree of safety, and to what extent are such additions likely to be warranted?

2. *The Object of Protective Gear.*

(*a*) In the simplest circuit, consisting of one generator, two conductors, and a motor, the generator requires to be protected from the effects of any one of the following possibilities :—

(i) Excessive overload upon the motor.
(ii) Short circuit in the windings of the motor, or loss of field.
(iii) Short circuit between the conductors.
(iv) Earthing of both conductors simultaneously.
(v) If a point in the generator windings is earthed, an earth leak anywhere else in the system.
(vi) A short circuit in the windings of the generator.

(*b*) The conductors require protection from the same possibilities, except for the last.

(*c*) The motor requires protection from (i), (ii) and (v).

(*d*) If there are several motors, every consumer should be protected, not only from these risks, but also from the inconvenience of a shut down, resulting from an accident to the gear of any other consumer.

(*e*) In a network system, every consumer should be protected from the risk of failure of supply resulting from an accident to any portion of the system.

(*f*) In any case, the General Public should be protected from the risks to life and property, that may arise in consequence of any defect in any portion of the system.

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(*g*) Where the pressure or type of current varies in different parts of the system, the transformers, converters, frequency changers, etc., require protection, both as motors, or consumers of power, and also as generators as regards their own distribution systems.

3. *The Insufficiency of Fuses.*

Fuses provide protection against overload, whether due to excessive demand for power, or developed through leakage, in any part of the system supplied through those fuses. They cannot be fitted in a suitable position to protect a generator from the effects of a fault in its own windings.

Fuses are somewhat unreliable; their replacement after they have blown is not always easy, and their power of discrimination is limited. For instance, a large and sudden leak, in the gear of one consumer, may "blow" a fuse which also carries the supplies of other consumers. Two-pole or triple-pole fuses seldom blow simultaneously: and after one has melted and broken the circuit, the conductors may be left alive.

4. *Overload Automatic Switches.*

The shortcomings of fuses are mostly absent from automatic switches, fitted with overload relays. However, in order to equal the virtue of fuses, in carrying brief overloads, such switches require to be provided with some delaying action. It is normal to fit every important overload switch with a delay action relay, generally in the form of a rotating disk ammeter, loaded so that it cannot develop sufficient torque to begin to turn, unless the current should exceed full load value by some predetermined amount. When the disc revolves under such overload conditions, which may normally be 125% to 200% of full load, it is made to raise a weight, and also to drag slowly through the field of a permanent magnet, designed to delay the trip action for some definite period, such as half a minute. At the end of this period, if the overload still continues, the weight reaches a trigger or contact, by means of which the switch is made to open, generally through the action of a second relay, such as a solenoid and plunger.

Such switches are very reliable. They open all poles simultaneously, so that no conductors can be left alive. Discrimination can be provided to a considerable extent, by setting switches nearer the source of supply to open only under greater overloads, and with more delay, than those further away. Thus, for instance, a defective distributor should be isolated before the feeder switch can open.

There is one state of affairs in which overload devices are unsatisfactory, namely, where several units or feeders supply the same busbars. An overload on one will mean that all are to some extent

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overloaded; and the opening of one switch will cause all the others to trip out in rapid succession, thus completely disorganising the supply of power. Overload trips are naturally in disfavour in such cases, and, if they are provided, operators are tempted to disconnect them and risk consequences.

Yet some form of protection is necessary; otherwise, if the insulation of one generator or feeder should break down, or if the field of one generator should fail, the others would pour back energy into the defective one, and great damage might result.

5. *Reverse Power Relays.*

For positions such as the last considered, Reverse Power Relays are of value for protecting plant. In alternating current circuits, these relays must be of the two magnet type, in order to be able to discriminate between the directions of the flow of power. One of these magnets is energised by a series coil, the current in which must be in phase with the supply. The other is energised by a shunt coil, across two conductors, and is designed with sufficient inductance to provide a flux in quadrature with the supply current in the series coil.

The relay disc, set between these magnets, develops a torque, like the rotor of a squirrel cage induction motor. Reversal of power in the cable causes the series field to change 180°, thus reversing the direction of rotation of the combined field, and therefore reversing the direction of the torque. Shunts may be used to divert most of the line current from the series coils; and in extra high tension lines it is usual to provide power to the relays through current and potential transformers.

The disc may be fitted with a projection, which normally engages a stop; so that no movement may occur unless the torque is reversed. When the disc revolves, under the influence of such a reversed torque, it trips out the switch by some means; for instance, by closing the circuit of a solenoid. It is usual to load such relays, and also to give them a time lag; so that they may not trip the switch on the occurrence of occasional reverse power, of an order and duration which is unlikely to cause trouble. Too sensitive a relay may increase the difficulty of parallelling in a set on to the busbars. Overload and Reverse Power sensitivity may be combined in the same relay. In this case, the disc is left free to revolve in either direction, subject to suitable loading and drag, and is arranged to trip the switch after a predetermined amount of movement either way; but the reverse movement may be more lightly loaded, and provided with less lag than the overload movement.

6. *Discrimination in Protective Devices.*

Protective gear is said to be discriminating when it is only sensi-

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tive to faults in the conductors to which it is applied, and is arranged to be unaffected by faults which may develop in other parts of the system. For instance, in a network system, one sub-station may be supplied by several feeders. It is advisable, since continuity of supply is the main object of providing the network, that any protective gear, that may be fitted in this case, should be fully discriminating. In other words, a fault in one feeder should cause the switches of that feeder to open, leaving all the others closed; so that the supply may not be cut off from the sub-station.

It will be sufficient to consider gear designed for three-phase E.H.T. systems; since gear for lower tension, and for single and two-phase systems, may be designed upon the same principles. Many different systems of protection have been evolved, varying widely in the matter of expense and complication, the degree of protection afforded, and in discriminating power. One system may be suitable for protecting the cables of a network, and another may be better for taking care of transformers. The matter of cost will be normally the ruling factor in the choice. Discriminating protective gear generally depends for its action on one of two main rules, which are self-obvious, namely :—

(i) In any insulated conductor, the flow of current must be equal throughout its length, except for a small charging current. The ampères leaving at the far end must be very nearly equal to the ampères entering at the generator end.

(ii) In a polyphase cable, the total current flowing in the cores should have an algebraic sum of zero, unless some power returns via the earth, *i.e.*, through a fault.

7. Ferranti-Field Protection.

In Fig. 1 is illustrated a simple and cheap form of protective gear, known by the name of Ferranti-Field. The cable, including the fourth wire if present, is surrounded by the laminations of a Ferranti-Field current transformer, which are split to facilitate assembly. Leads are taken from the secondary winding to a suitable relay, capable of tripping the switch controlling the cable, if any appreciable amount of current is induced in the secondary.

So long as the sum of the currents in the cores is zero, none will be so induced; but if a fault to earth occurs anywhere in the portion of the system fed through the cable, the power which returns via the earth must pass through the current transformer to the seat of the fault, and must therefore induce some current in the secondary. Thus any fault to earth, if of sufficient magnitude, will cause the relay to operate.

Such gear affords no protection against faults between phases; nor is it discriminating, for a fault in any portion of the distribution system may bring out the feeder switches.

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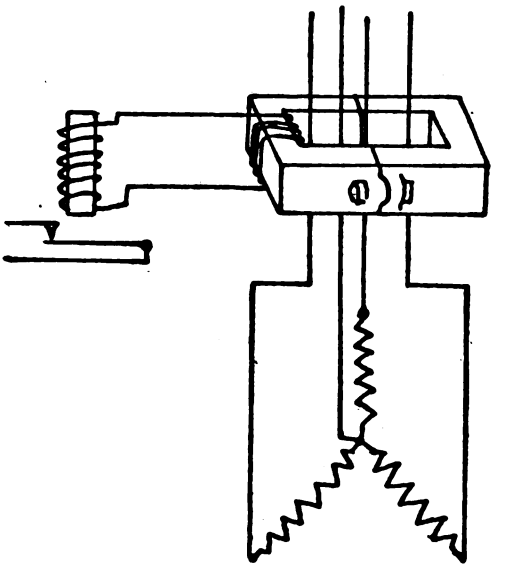

Fig. 1. Ferranti-Field.

It is valuable for protecting generators from the effects of faults to the frame; for, if the neutral point in the windings is earthed through a wire, and the current transformer embraces both this earthing wire and the supply cable, then any leakage to the frame must return through the current transformer.

8. *Self-Balancing Protection.*

A slightly less simple, but much more effective method of protecting generators and transformers, is the self-balancing system illustrated in Fig. 2.

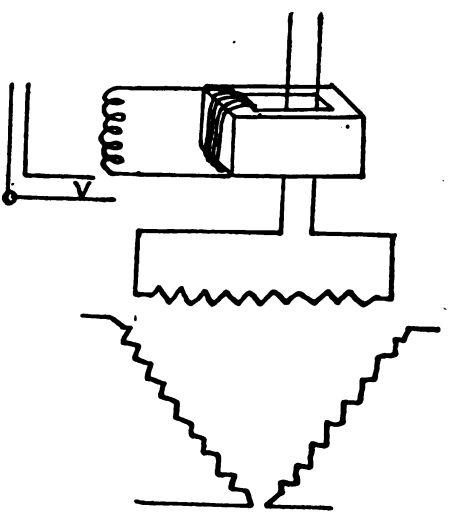

Fig. 2. Self-Balancing.

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Both ends of every winding are brought out of the machine, and the two ends of a winding pass through a current transformer, connected to a switch tripping relay.

Any leakage in the machine, whether to earth or between phases, will cause the currents in the two ends of a winding to be unequal; and, if the difference is sufficiently great, enough current will be induced in the secondary to actuate the relay, and open the switch. This gear is fully discriminating, for nothing but a fault in the winding concerned can cause the relay to act. No protection is afforded against loss of field; nor against the effects of a short circuit between turns of the same winding.

9. *Ferranti-Hawkins Protection.*

Two Ferranti-Field transformers, placed one at either end of a cable, as in Fig. 3, and connected in opposition through a pilot wire and relays, constitute the Ferranti-Hawkins system of cable protection.

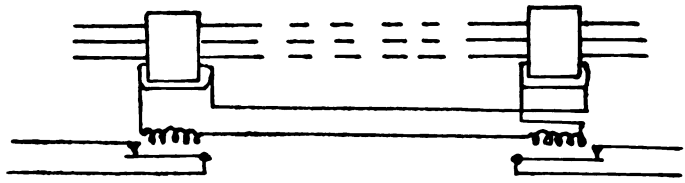

Fig. 3. Ferranti-Hawkins.

A fault to earth in the cable causes one transformer to develop a secondary current; since the fault current must pass through the cable to the seat of the trouble, either through the transformer at one end only, or in different directions through both ends.

Any fault *elsewhere in the system* is fed through both transformers in the same direction, and so can produce no currents in the two opposed secondaries. Thus this system is completely discriminating. It affords no protection against faults between phases.

10. *Merz-Price Protection.*

The Merz-Price system of protection may be regarded as a development of the Ferranti-Hawkins, giving protection from leakage between phases, at the cost of increasing the amount of gear. Every phase is separately protected; and this requires six transformers instead of two, and at least three pilot wires.

There is a difference between the methods of wiring systems for the protection of cables and machines, due to the very different lengths of pilot wire required.

In the case of cables, whose pilot wires must be long, it is usual to oppose the *potentials* of the two transformers on a phase, so that no current may pass until a fault develops in that phase. This is known

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as *Potential balancing*, and is effective with carefully balanced transformers and delicate relays. In the case of machines, whose pilot wires may be short, it is normal to use the *current balancing* method illustrated in Fig. 4.

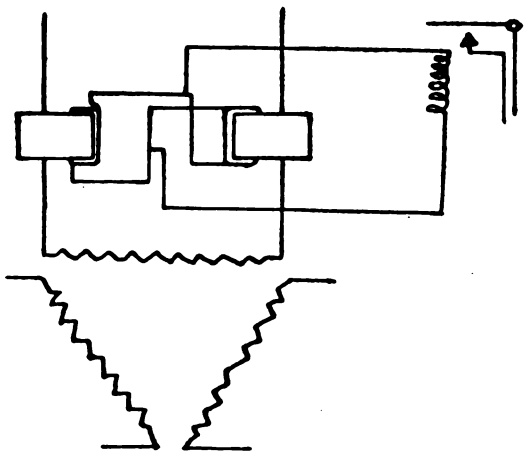

Fig. 4. Merz-Price, Current Balancing.

The transformers are connected in series, so that a current circulates in them whenever there is any demand for power. The relay is connected across the mid-points of the pilot-wires; and therefore receives no current if the induced currents in the transformer secondaries are equal. If one should pass more current than the other, the *difference* must flow through the relay.

The reason for the adoption of this principle of current balancing is, that current transformers can be made to give a more nearly straight line ratio-load curve, if a current is permitted to flow through the secondaries, opposing the excitation of the core. Thus the flux in the iron remains more nearly constant, and also on the straight line portion of the B.H. curve for the iron. If no current is permitted to circulate in the secondaries, such a low intensity of flux can seldom be ensured, except by the inclusion in the magnetic circuit of complications in the form of air gaps, to raise the reluctance of the path.

In the case of cables, potential balancing permits the use of lighter pilot wires, and saves losses in power, which outbalance the extra cost of potentially balanced transformers. The relays must be very sensitive; and here arises a difficulty, in the danger that they may respond to chance currents, induced in the pilot wires by external causes. In order to avoid such trouble, it is usual to enclose the three pilot wires in one cable, in which earthed screening tubes are introduced, one surrounding each wire. These are known as "compensated pilot-wire" cables.

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11. *Split Conductor Protection.*

In this system the expense of providing pilot wires is saved, and the risk of operation of relays by induced currents is avoided, at the price of supplying a six core cable. Thus no extra copper is required, but some extra expense in insulation is necessary.

The current in any phase is equally divided between two cores and these are led in opposite directions through a current transformer in whose secondary no current can be induced so long as the balance is maintained. Any leakage from one of a pair, whether to earth, or to another phase, destroys the balance of current in the "splits," and causes the transformer to operate a relay. Discrimination is complete; and protection is provided against faults to earth and between phases, unless both cores of a phase should be simultaneously earthed through faults of identically equal resistance, a most unlikely event. For overhead lines this system presents the interesting feature that the breakage of any one of the six conductors may be made to isolate the line instantly, before the broken wire can touch anything or endanger life or property.

12. *Callender-Hunter Protection.*

All the advantages of the split conductor system of protection can be obtained by splitting only one of the conductors, if all the conductors are woven through a laminated iron ring, as shewn diagramatically in Fig. 5. Any fault in one of the undivided conductors will

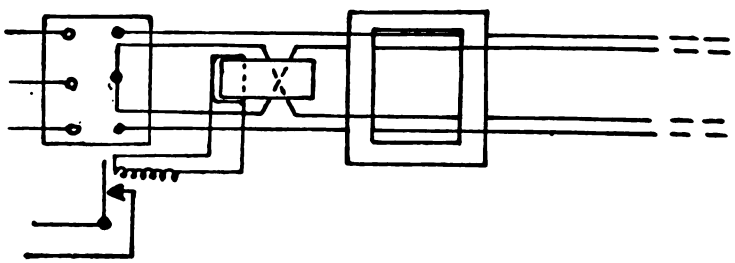

Fig. 5. Callender Hunter.

then induce a circulating current in the halves of the split core, destroying the balance, and so causing the relays to operate. This system incidentally affords protection against a fault between the halves of the split core; for the inductances at the ends of the cable always produce opposing E.M.F's. in the split core, which normally balance, so that no current circulates. A fault between the halves permits both currents to circulate through the fault, and so operates the relays at both ends.

13. *Ferranti-Waters Protection.*

When the conductors of a cable are split, but all contained in the same sheath, damage to any one necessitates isolation of the whole

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cable. Therefore two or more entirely separate cables are sometimes provided, working in parallel.

They may be balanced as complete cables, and protected separately by relays on the Ferranti-Field or the Merz-Price system. The Ferranti-Waters system protects without the use of long pilot wires, by balancing one cable against the other.

The two or more " generator ends " may be balanced by current transformers connected in opposition through a simple relay, set to open the switches if the power taken through the cables should become unequal. It is preferable to fit one relay per cable, or even one per core, of the reverse power discriminating type, so that only the defective cable may be isolated, leaving the other or others to carry the load, and so maintain continuity of supply.

At the receiving ends, reverse power relays are essential when only two cables are provided; for, if there happened to be no demand for power when a fault developed in one cable, the power flowing outward through the sound cable, and back through part of the damaged one to the seat of trouble, would balance. In that case the relays might not operate for some considerable time, if they were unable to discriminate between directions of flow of power. Separate reverse power relays would meet the case; but, since it is necessary that any *difference* in power transmitted by two cables should cut out that carrying the smaller amount, the relays should be coupled in opposition. Fig. 6 illustrates the principle, applied

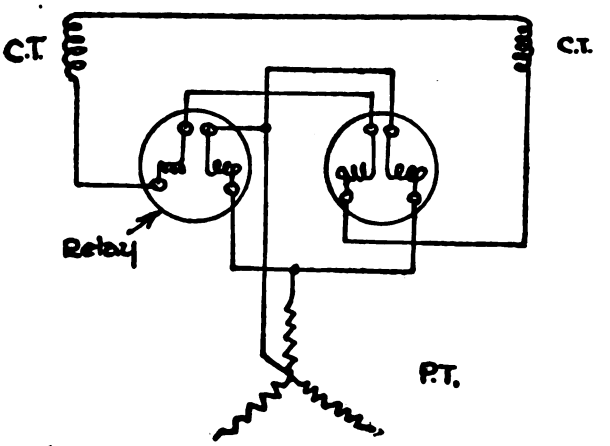

Fig. 6. Ferranti-Waters.

to protect against earth faults only. Separate protection for every phase can be similarly applied, but the gear then becomes somewhat complicated.

14. *Callender-Waters Protection.*

The Callender-Waters system of protection is dependent upon an entirely different principle from those already described.

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Surrounding the insulation of the cable, and lightly insulated from the sheath or armouring, are placed six tapes of copper. Of these, three are connected to earth at one end, through a relay, and the other three at the other end. It is almost impossible for a core to develop a fault to earth without touching one of the tapes. Even if the tape should be well earthed at the fault, the surge of current through the faulty core would induce a considerable current in the tape, whose two earths would make it a closed circuit, including the relay. Contact, with one tape only, might bring out the switch at one end only, leaving the cable live. To guard against this it is common to provide an auxiliary contact in the switch, set to connect one of the other tapes with a battery whose other pole is earthed when the switch opens. Thus the opening of one switch causes the other, at the far end of the cable, to follow, completing the isolation of the cable.

15. *Ferranti Surge Absorber.*

Protection against the effects of lightning and sudden breaks in the circuit, which may cause high frequency surges and steep fronted waves, are discussed to some extent in *Military Engineering (Technical Training), Vol. II, Electrical Engineering.* Horn arrestors, and other spark gap types of protective device, suffer from the disadvantage that they can only permit disturbances to dissipate their energy, by allowing an arc to form to earth. This arc tends to persist ; and, if it is broken at an inopportune instant, it may cause further disturbances of even greater destructive power.

Choking coils and condenser devices, while they protect plant, are apt to reflect waves back into the line. Moreover, they are often troublesome to keep in working order. The Ferranti Surge Absorber is a device intended to absorb the energy in such disturbances without the formation of an arc, and without reflecting waves back into the line. Fig. 7 illustrates in simple diagram the principle on which such an absorber is designed.

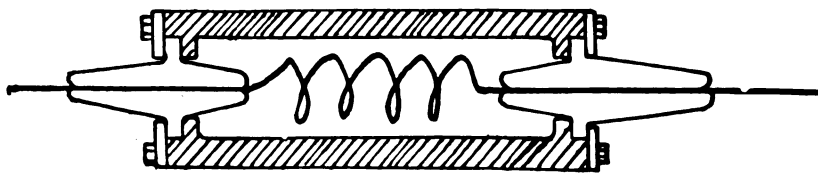

Fig. 7. Ferranti Surge Absorber.

One absorber is necessary for every core or conductor, and is generally fitted near the point where the latter is led in to the station or sub-station. An absorber consists mainly of a few turns, normally about sixty, of copper conductor, well insulated, and carried in a shell, built of a special iron, which is nearly non-magnetic and of a high specific resistance. The absorber operates as a transformer,

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of which the primary (the sixty turns of copper), is interposed in the power line circuit. The shell constitutes a secondary, of one short circuited turn, of low resistance. Since any change of flow in the primary must cause a flow of the order of sixty times its value in the shortcircuited secondary, the normal power current causes an alternating flow of large magnitude in the shell. The heating effect of this induced flow depends upon the resistance of the shell; and it is normally designed to be of the order of one watt at full load.

Surges of oscillatory frequency, or other steep crested waves, in sweeping along the line, cause the steep gradients of potential which are apt to produce flashing over or rupture of insulators, puncturing of the insulation of transformers, and other damage, against which the surge absorbers are intended to be a protection. Such surges consist of large local charges, travelling at very high velocity. This is equivalent to a local momentary flow of current of very large magnitude. Surges induced by lightning flashes probably attain a current value of a hundred thousand ampères.

When such a surge enters an absorber, momentary currents of the order of six million ampères are induced in the shell. Since the heating effect of the current is proportional to I^2R, the loss in the shell is very large, in spite of the low ohmic resistance offered. Thus the energy represented in the surge is mostly converted to heat; and since this is a non-reversible change, no reflection into the line can take place.

Briefly summarised, the effect of the absorber is that of a transformer, producing, in a secondary circuit of small resistance, currents of a much higher order than those flowing in the power line. Since heating losses are as the square of current values, the losses in this secondary circuit may be arranged to be negligible as regards normal power load, but powerfully damping to violent surges.

Moreover, the heat generated in this secondary circuit is produced in a resistance whose thermal capacity is ample, and its radiating surface large. Thus all danger of fusing or starting a conflagration is eliminated; for surges are generally of short duration, and seldom follow without sufficient interval to allow the shell to cool down in between disturbances.

16. *McColl Alternator Protection.*

In the case of a generator, the mere provision of relays, set to open the switches if a fault should develop in the windings of the machine, is insufficient protection; for, after the switch has opened, the generator may still continue to damage itself, unless it is definitely rendered incapable of generating electrical energy.

In the McColl system of Alternator protection any fault in the generator is made to operate several relays. One opens the main

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switch, while another stops the excitation of the field, and short-circuits the field coils.

A third relay may be provided, in the case of generators cooled by forced air circulation, to start up a motor, and thereby to close the air ducts, and isolate any conflagration that may have started in the machine.

The relays may be of a simple beam type, sensitive only to leakage faults; but a greater degree of protection may be provided by fitting induction relays, which are also sensitive to reversal of power, whether due to weak or lost field, or to failure of the prime-mover.

17. *Special Considerations.*

Limitation of space prohibits more than a cursory review of the circumstances in which protection may be desirable, and of the means available to meet the needs.

One of the systems that have been considered in these notes will generally be applicable to any case; but sometimes a little thought may be necessary, to avoid obvious pitfalls.

For instance, a system, such as Merz-Price, which is normally applicable to a cable, may be used equally well to protect a transformer; but it must be remembered that the currents entering and leaving the transformer will have very different values as expressed in ampères.

The question of ratio is easily dealt with in the design of the current transformers, on the H.T. and L.T. leads respectively; but the matter of losses is not quite so simple. They may be met by a definite loading of the relays: for it follows that, if the losses greatly exceed those calculated for full load working, then either the transformer is grossly overloaded, or there must be some internal fault. Copper losses are fairly well proportional to the load, and can be compensated in the design of the current transformers. Therefore it is usual to leave only the iron losses to be met by loading the relays.

Switchboards may be protected by insulating the framework lightly from the ground, and earthing it through a relay. Detail gear, such as the current transformers on feeders, should be earthed by separate wires, each with its own relay; so that the failure of one may only bring out the switch of its own cable, and not cut off the supply of sound feeders. It is very important to realise that protection, if applied without due regard for power of discrimination, soon becomes an intolerable nuisance.

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BATTLE HONOURS OF ROYAL ENGINEER UNITS.

ERRATA.

Page 438.

PILCKEM. 31ST JULY-2ND AUGUST, 1917.

Unit.	Formation.	E.	Remarks.
IV CORPS.			
Field—			
455th (W. Riding)	Field Co. 29th Divn.	E.	
510th (London	,, ,,	,,	
497th (Kent)	,, ,,	N.E.	

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switch, while another [illegible]

BATTLE HONOURS OF ROYAL ENGINEER UNITS (continued).

N.B. "SOMME 1918" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM ST. QUENTIN TO VILLERS BRETONNEUX.

ST. QUENTIN. 21ST-23RD MARCH, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
G Special (Projector) Co.	Special Bde.	E.	
J ,,	,,	,,	
Q ,,	,,	,,	
No. 3 Special (Mortar) Co.	,,	N.E.	
132nd Army Troops Co.	VI Corps	,,	
142nd ,,	IV ,,	,,	
147th ,,	V ,,	E.	
149th ,,	IV ,,	D.	
232nd ,,	VI ,,	N.E.	
280th ,,	V ,,	E.	
559th ,,	V ,,	,,	
565th ,,	VI ,,	,,	
577th ,,	V ,,	,,	No diary.
7th R. Monmouth Army Troops Co.	IV ,,	N.E.	
No. 1 Siege Co. R. Monmouth	VI ,,	,,	
174th Tunnelling Co.	VI ,,	E.	
175th ,,	V ,,	,,	No diary.
181st ,,	VI ,,	N.E.	
252nd ,,	IV ,,	E.	
257th ,,	VI ,,	N.E.	
2nd Australian Tun. Co.	V ,,	E.	
New Zealand ,,	XVII & VI Corps	N.E.	
No. 352 E. & M. Co.		D.	No diary.
No. 3 Field Survey Co.		,,	No diary.
No. 3 Pontoon Park	V Corps	E.	
No. 1 Foreway Co.	IV ,,	D.	No records.
No. 2 ,,	XVII & VI Corps	N.E.	
No. 3 ,,	V Corps	E.	
IV CORPS.			
12th Field Co.	6th Div.	E.	
459th ,,	,,	,,	
509th ,,	,,	,,	
81st ,,	19th Div.	,,	
82nd ,,	,,	,,	
94th ,,	,,	,,	
105th ,,	25th Div.	,,	
106th ,,	,,	,,	
130th ,,	,,	,,	
228th ,,	41st Div.	,,	
233rd ,,	,,	,,	
237th ,,	,,	,,	
400th ,,	51st Div.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
V CORPS.			
5th Field Co.	2nd Div.	E.	
226th ,,	,,	,,	
483rd ,,	,,	,,	
77th ,,	17th Div.	,,	
78th ,,	,,	,,	
93rd ,,	,,	,,	

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ST. QUENTIN, 21ST-23RD MARCH, 1918.

Unit.	Formation.	Remarks.
V CORPS.		
517th Field Co.	47th Div.	E.
518th ,,	,,	,,
520th ,,	,,	,,
247th ,,	63rd Div.	,,
248th ,,	,,	,,
249th ,,	,,	,,
VI CORPS.		
55th Field Co.	Guards Div.	N.E.
75th ,,	,,	,,
76th ,,	,,	,,
56th ,,	3rd Div.	,,
438th ,,	,,	D.
529th ,,	,,	N.E.
210th ,,	31st Div.	,,
211th ,,	,,	,,
223rd ,,	,,	,,
207th ,,	34th Div.	E.
208th ,,	,,	,,
209th ,,	,,	,,
224th ,,	40th Div.	,,
229th ,,	,,	,,
231st ,,	,,	,,
467th ,,	59th Div.	,,
469th ,,	,,	,,
470th ,,	,,	,,
FIFTH ARMY.		
ARMY TROOPS.		
5th Field Squadron.	5th Army	E.
A Special (Projector) Co.	Special Bde.	,,
E ,,	,,	,,
H ,,	,,	,,
No. 1 Special (Mortar) Co.	,,	,,
135th Army Troops Co.	III Corps	,,
144th ,,		N.E.
146th ,,	VII Corps	D. No diary.
213th ,,	5th Army	N.E.
216th ,,	XVIII Corps	D.
217th ,,	5th Army	N.E.
221st ,,	VII Corps	E.
238th ,,	VII ,,	,,
239th ,,	XIX ,,	,,
281st ,,	XIX ,,	,,
283rd ,,	XI ,,	D.
284th ,,	III ,,	E.
288th ,,	XIX ,,	,,
567th ,,	III ,,	,,
568th ,,	III ,,	,,
574th ,,	VII ,,	D. No diary.
No. 1 Siege Co. R. Anglesey	XVIII ,,	E.
No. 4 Siege Co. R. Anglesey	III ,,	,, No diary.
172nd Tunnelling Co.	XVIII ,,	,,
173rd ,,	XIX ,,	D.
177th ,,	VII ,,	E.
178th ,,	VII ,,	,, Diary missing.
180th ,,	VII ,,	,,
182nd ,,	III ,,	,,
253rd ,,	XIX ,,	D.
255th ,,	XIX ,,	E.
No. 353 E. & M. Co.		D.
No. 5 Field Survey Co.		,,
No. 6 Foreway Co.	XVIII Corps	E.

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ST. QUENTIN, 21ST-23RD MARCH, 1918.

Unit.	Formation.	Remarks.
III CORPS.		
2nd Field Squadron	2nd Cavy. Divn.	E.
3rd ,,	3rd ,,	,,
61st Field Co.	14th Div.	,,
62nd ,,	,,	,,
89th ,,	,,	,,
79th ,,	18th Div.	,,
80th ,,	,,	,,
92nd ,,	,,	,,
503rd ,,	58th Div.	,,
504th ,,	,,	,,
511th ,,	,,	,,
VII CORPS.		
63rd Field Co.	9th Div.	E.
64th ,,	,,	,,
90th ,,	,,	,,
155th ,,	16th Div.	,,
156th ,,	,,	,,
157th ,,	,,	,,
97th ,,	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,
225th ,,	39th Div.	,,
227th ,,	,,	,,
234th ,,	,,	,,
XVIII CORPS.		
83rd Field Co.	20th Div.	E.
84th ,,	,,	,,
96th ,,	,,	,,
200th ,,	30th Div.	,,
201st ,,	,,	,,
202nd ,,	,,	,,
121st ,,	36th Div.	,,
122nd ,,	,,	,,
150th ,,	,,	,,
476th ,,	61st Div.	,,
478th ,,	,,	,,
479th ,,	,,	,,
XIX CORPS.		
1st Field Squadron	1st Cav. Div.	E.
2nd Field Co.	8th Div.	N.E.
15th ,,	,,	,,
490th ,,	,,	,,
103rd ,,	24th Div.	E.
104th ,,	,,	,,
129th ,,	,,	,,
7th ,,	50th Div.	,,
446th ,,	,,	,,
447th ,,	,,	,,
430th ,,	66th Div.	,,
431st ,,	,,	,,
432nd ,,	,,	,,

SIGNALS.

ST. QUENTIN. 21ST-23RD MARCH, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.	3rd Army	D.
D Corps Signal Co.	IV Corps	E.
6th Divl. Sig. Co.	,,	,,
19th ,,	,,	,,
25th ,,	,,	,,
41st ,,	,,	,,
51st ,,	,,	,,

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SIGNALS.

ST. QUENTIN. 21ST-23RD MARCH, 1918.

Unit.	Formation.	Remarks.
O Corps Signal Co.	V Corps	E.
2nd Divl. Sig. Co.	,,	,,
17th ,,	,,	,,
47th ,,	,,	,,
63rd ,,	,,	,,
F Corps Signal Co.	VI Corps	D.
Guards Divl. Sig. Co.	,,	,,
3rd ,,	,,	,,
31st ,,	,,	,,
34th ,,	,,	E.
40th ,,	,,	,,
59th ,,	,,	,,
Fifth Army Signal Co.	5th Army	D.
Cavalry Corps Signal Co.	Cav. Corps.	,,
1st Signal Squadron	1st Cav. Div.	E.
2nd ,,	2nd ,,	D.
3rd ,,	3rd ,,	E.
C Corps Signal Co.	III Corps	,,
14th Divl. Sig. Co.	,,	,,
18th ,,	,,	,,
58th ,,	,,	,,
G Corps Signal Co.	VII Corps	,,
9th Divl. Sig. Co.	,,	,,
16th ,,	,,	,,
21st ,,	,,	,,
29th ,,	,,	,,
S Corps Signal Co.	XVIII Corps	,,
20th Divl. Sig. Co.	,,	,,
30th ,,	,,	,,
36th ,,	,,	,,
61st ,,	,,	,,
T Corps Signal Co.	XIX Corps	,,
8th Divl. Sig. Co.	,,	D.
24th ,,	,,	E.
50th ,,	,,	,,
66th ,,	,,	,,

BAPAUME, 1918 (FIRST BATTLE). 24TH-25TH MARCH, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
G Special (Projector) Co.	IV Corps	N.E.	
J ,,	VI ,,	,,	
Q ,,	V ,,	,,	
No. 3 Special (Mortar) Co.	VI ,,	E.	
132nd Army Troops Co.	VI ,,	N.E.	
142nd ,,	IV ,,	E.	
147th ,,	V ,,	,,	
149th ,,	IV ,,	D.	
232nd ,,	VI ,,	,,	
280th ,,	V ,,	E.	
282nd ,,	XVII ,,	D.	
550th ,,	V ,,	E.	
565th ,,	VI ,,	,,	
577th ,,	V ,,	D.	No diary.
7th R. Monmouth Army Troops Co.	IV ,,	E.	
No. 1 Siege Co. R. Monmouth	VI & XVII Corps	N.E.	
174th Tunnelling Co.	VI Corps	E.	
175th ,,	V ,,	D.	No diary.
179th ,,	XVII ,,	E.	
181st ,,	VI ,,	,,	
252nd ,,	IV ,,	,,	

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BAPAUME, 1918 (FIRST BATTLE), 24TH-25TH MARCH, 1918.

Unit.	Formation.		Remarks.
ARMY TROOPS.			
257th Tunnelling Co.	VI & XVII Corps	E.	
2nd Aust. ,,	V Corps	,,	
N.Z. ,,	XVII & VI Corps	N.E.	
No. 352 E. & M. Co.		D.	No diary.
3rd Field Survey Co.		,,	No diary.
No. 364 Forestry Co.	V Corps	,,	No diary.
No. 3 Pontoon Park	V ,,	E.	
No. 1 Foreway Co.	IV ,,	D.	No records.
No. 2 ,,	VI ,,	E.	
No. 3 ,,	V Corps	,,	
IV CORPS.			
81st Field Co.	19th Div.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
105th ,,	25th Div.	,,	
106th ,,	,,	,,	
130th ,,	,,	,,	
228th ,,	41st Div.	,,	
233rd ,,	,,	,,	
237th ,,	,,	,,	
400th ,,	51st Div.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
457th ,,	62nd Div.	,,	
460th ,,	,,	,,	
461st ,,	,,	,,	
V CORPS.			
5th Field Co.	2nd Div.	E.	
226th ,,	,,	,,	
483rd ,,	,,	,,	
69th ,,	12th Div.	N.E.	
70th ,,	,,	,,	
87th ,,	,,	,,	
77th ,,	17th Div.	E.	
78th ,,	,,	,,	
93rd ,,	,,	,,	
517th ,,	47th Div.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
247th ,,	63rd Div.	,,	
248th ,,	,,	,,	
249th ,,	,,	,,	
VI CORPS.			
55th Field Co.	Guards Div.	E.	
75th ,,	,,	,,	
76th ,,	,,	,,	
56th ,,	3rd Div.	,,	
438th ,,	,,	,,	
529th ,,	,,	,,	
210th ,,	31st Div.	,,	
211th ,,	,,	,,	
223rd ,,	,,	,,	
207th ,,	34th Div.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
224th ,,	40th Div.	,,	
229th ,,	,,	,,	
231st ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
467th ,,	59th Div.	D.	
469th ,,	,,	,,	
470th ,,	,,	N.E.	

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BAPAUME, 1918 (FIRST BATTLE), 24TH-25TH MARCH, 1918.

Unit.	Formation.	Remarks.
XVIII Corps.		
73rd Field Co.	15th Div.	E.
74th ,,	,,	,,
91st ,,	,,	,,
9th ,,	4th Div.	N.E.
406th ,,	,,	,,
526th ,,	,,	,,
Fifth Army.		
Army Troops.		
No. 1. Special (Mortar) Co.	VII Corps	E.
146th Army Troops Co.	,,	D. No diary.
221st ,,	,,	N.E.
238th ,,	,,	,,
574th ,,	,,	D. No diary.
177th Tunnelling Co.	,,	E.
178th ,,	,,	,,
180th ,,	,,	,,
VII Corps.		
1st Field Squadron	1st Cav. Div.	N.E.
63rd Field Co.	9th Div.	E.
64th ,,	,,	,,
90th ,,	,,	,,
97th ,,	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,
203rd ,,	35th Div.	,,
204th ,,	,,	,,
205th ,,	,,	,,

SIGNALS.

BAPAUME, 1918 (FIRST BATTLE). 24TH-25TH MARCH, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.		N.E.
D Corps Signal Co.	IV Corps	E.
19th Divl. Signal Co.	,,	,,
25th ,,	,,	,,
41st ,,	,,	,,
51st ,,	,,	,,
62nd ,,	,,	,,
O Corps Signal Co.	V Corps	,,
2nd Divl. Signal Co.	,,	,,
12th ,,	,,	N.E.
17th ,,	,,	E.
47th ,,	,,	,,
63rd ,,	,,	,,
F Corps Signal Co.	VI Corps	D.
Guards Divl. Signal Co.	,,	E.
3rd ,,	,,	,,
31st ,,	,,	,,
40th ,,	,,	,,
42nd ,,	,,	,,
50th ,,	,,	N.E.
R Corps Signal Co.	XVII Corps	D.
15th Divl. Signal Co.	,,	E.
Fifth Army Signal Co.		N.E.
G Corps Signal Co.	VII Corps	D.
1st Cav. Div. Signal Co.	,,	,,
9th Divl. Signal Co.	,,	E.
21st ,,	,,	,,
35th ,,	,,	,,

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ROSIERES. 26TH-27TH MARCH, 1918.

Unit.	Formation.		Remarks.
FIFTH ARMY.			
ARMY TROOPS.			
5th Field Squadron	XIX Corps	E.	1st R.E. Batn.
A Special (Projector) Co.	XVIII ,,	,,	
E ,,	XVIII ,,	,,	
H ,,	XVIII ,,	,,	
No. 1 Special (Mortar) Co.	VII ,,	N.E.	
144th Army Troops Co.	Fifth Army	E.	
146th ,,	VII Corps	D.	No diary.
213th ,,	Fifth Army	E.	
216th ,,	XVIII Corps	,,	
217th ,,	Fifth Army	,,	Carey's Force.
221st ,,	VII Corps	N.E.	
238th ,,	VII ,,	,,	
239th ,,	XIX ,,	E.	C. Co. 1st R.E. Batn.
281st ,,	XIX ,,	,,	C. Co. 1st R.E. Batn.
283rd ,,	XIX ,,	,,	D. Co. 1st R.E. Batn.
288th ,,	XIX ,,	,,	D. Co. 1st R.E. Batn.
574th ,,	VII ,,	D.	No diary.
No. 1 Siege Co. R. Anglesey	XVIII ,,	E.	
172nd Tunnelling Co.	XVIII ,,	,,	
173rd ,,	XIX ,,	,,	A. Co. 1st R.E. Bat.
253rd ,,	XIX ,,	,,	
258th ,,	XIX ,,	,,	B. Co. 1st R.E. Bat.
No. 353 E. & M. Co.		D.	No diary.
5th Field Survey Co.		E.	Carey's Force.
No. 6 Foreway Co.	XVIII Corps	,,	
XVIII CORPS.			
83rd Field Co.	20th Div.	E.	
84th ,,	,,	,,	
96th ,,	,,	,,	
200th ,,	30th Div.	,,	
201st ,,	,,	,,	
202nd ,,	,,	,,	
121st Field Co.	36th Div.	,,	
122nd ,,	,,	,,	
150th ,,	,,	,,	
476th ,,	61st Div.	,,	
478th ,,	,,	,,	
479th ,,	,,	,,	
XIX CORPS.			
2nd Field Co.	8th Div.	E.	
15th ,,	,,	,,	
490th ,,	,,	,,	
155th ,,	16th Div.	,,	
156th ,,	,,	,,	
157th ,,	,,	,,	
103rd ,,	24th Div.	,,	
104th ,,	,,	,,	
129th ,,	,,	,,	
225th ,,	39th Div.	,,	
227th ,,	,,	,,	
234th ,,	,,	,,	
7th ,,	50th Div.	,,	
446th ,,	,,	,,	
447th ,,	,,	,,	
430th ,,	66th Div.	,,	
431st ,,	,,	,,	
432nd ,,	,,	,,	

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SIGNALS.

ROSIERES. 26th-27th March, 1918.

Unit.	Formation.		Remarks.
Fifth Army Signal Co.	Fifth Army	N.E.	
S. Corps Signal Co.	XVIII Corps	D.	
20th Divl. Signal Co.	,,	E.	
30th ,,	,,	,,	
36th ,,	,,	,,	
61st ,,	,,	,,	
T. Corps Signal Co.	XIX Corps	D.	
8th Divl. Signal Co.	,,	E.	
16th ,,	,,	,,	
24th ,,	,,	,,	
39th ,,	,,	,,	
50th ,,	,,	,,	
66th ,,	,,	,,	

ARRAS, 1918 (FIRST BATTLE). 28th March, 1918.

Unit.	Formation		Remarks.
First Army.			
Army Troops.			
176th Tunnelling Co.	XIII Corps	E.	R.E. Batn. "B" Reserve Bde. 56th Div.
No. 4 Siege Co. R. Anglesey	,,	D.	No diary.
XIII Corps.			
416th Field Co.	56th Div.	E.	R.E. Batn.
512th ,,	,,	,,	
513th ,,	,,	,,	"B" Reserve Bde.
Third Army.			
Army Troops.			
G (Special) Projector Co.	IV Corps	N.E.	
J ,,	VI ,,	,,	
Q ,,	V ,,	,,	
No. 3 (Special) Mortar Co.	VI ,,	,,	
132nd Army Troops Co.	VI ,,	,,	
142nd ,,	IV ,,	,,	
147th ,,	V ,,	,,	
149th ,,	IV ,,	,,	
232nd ,,	VI ,,	E.	
280th ,,	V ,,	N.E.	
282nd ,,	XVII ,,	D.	Diary useless.
559th ,,	V ,,	N.E.	
565th ,,	VI ,,	E.	
577th ,,	V ,,	N.E.	
7th R. Monmouth ,,	IV ,,	E.	
No. 1 Siege Co. R. Monmouth	XVII ,,	,,	
174th Tunnelling Co.	VI ,,	,,	
175th ,,	V ,,	N.E.	
179th ,,	XVII ,,	E.	
181st ,,	VI ,,	,,	
252nd ,,	IV ,,	N.E.	
257th ,,	XVII ,,	E.	
2nd Aust. ,,	V ,,	N.E.	
N.Z. Tunnelling Co.	XVII ,,	E.	
No. 352 E. & M. Co.		D.	No diary.
3rd Field Survey Co.		,,	No diary.

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ARRAS, 1918 (FIRST BATTLE), 28TH MARCH, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
No. 3 Pontoon Park	V & VI Corps	N.E.	
No. 8 ,,	XVII Corps	,,	
No. 1 Foreway Co.	IV ,,	D.	No records.
No. 2 ,,	VI ,,	N.E.	
No. 3 ,,	V ,,	,,	
IV CORPS.			
228th Field Co.	41st Div.	E.	
233rd ,,	,,	,,	
237th ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
457th ,,	62nd Div.	,,	
460th ,,	,,	,,	
461st ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th Aust. ,,	4th Aust. Div.	N.E.	
12th ,,	,,	,,	
13th ,,	,,	,,	
81st Field Co.	19th Div.	D.	Within the area but not employed.
82nd ,,	,,	,,	
94th ,,	,,	,,	
V CORPS.			
5th Field Co.	2nd Div.	E.	
226th ,,	,,	,,	
483rd ,,	,,	,,	
69th ,,	12th Div.	N.E.	
70th ,,	,,	,,	
87th ,,	,,	,,	
VI CORPS.			
55th Field Co.	Guards Div.	E.	
75th ,,	,,	,,	
76th ,,	,,	,,	
56th ,,	3rd Div.	,,	
438th ,,	,,	,,	
529th ,,	,,	,,	
210th ,,	31st Div.	,,	
211th ,,	,,	,,	
223rd ,,	,,	,,	
206th ,,	32nd Div.	N.E.	
218th ,,	,,	,,	
219th ,,	,,	,,	
207th ,,	34th Div.	E.	
208th ,,	,,	,,	
209th ,,	,,	,,	
4th Can. ,,	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
XVII CORPS.			
9th Field Co.	4th Div.	E.	
406th ,,	,,	,,	
526th ,,	,,	,,	
73rd ,,	15th Div.	,,	
74th ,,	,,	,,	
91st ,,	,,	,,	

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SIGNALS.

ARRAS, 1918 (FIRST BATTLE). 28TH MARCH, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
N. Corps Signal Co.	XIII Corps	D.
56th Divl. Sig. Co.	,,	E.
Third Army Signal Co.		N.E.
D. Corps Signal Co.	IV Corps	D.
41st Divl. Sig. Co.	,,	E.
42nd ,,	,,	,,
62nd ,,	,,	,,
N.Z. ,,	,,	,,
4th Aust. Signal Co.	,,	N.E.
O. Corps Signal Co.	V Corps	D.
2nd Divl. Signal Co.	,,	,,
12th ,,	,,	,,
F. Corps Signal Co.	VI Corps	,,
Guards Divl. Signal Co.	,,	E.
3rd ,,	,,	,,
31st ,,	,,	,,
32nd ,,	,,	N.E.
2nd Can. ,,	,,	E.
R. Corps Signal Co.	XVII Corps	D.
4th Divl. Signal Co.	,,	E.
15th ,,	,,	,,

AVRE. 4TH APRIL, 1918.

Unit.	Formation.	Remarks.
FOURTH ARMY.		
ARMY TROOPS.		
135th Army Troops Co.	XIX Corps	E.
239th ,,	,,	,,
281st ,,	,,	,,
283rd ,,	,,	,,
288th ,,	,,	D.
173rd Tunnelling Co	,,	E.
258th ,,	,,	,,
XIX CORPS.		
3rd Field Squadron	3rd Cav. Div.	E.
5th ,,	Cav. Corps	D.
61st Field Co.	14th Div.	E.
62nd ,,	,,	,,
89th ,,	,,	,,
79th ,,	18th Div.	,,
80th ,,	,,	,,
92nd ,,	,,	,,
103rd ,,	24th Div.	D.
104th ,,	,,	N.E.
129th ,,	,,	,,
503rd ,,	58th Div.	,,
504th ,,	,,	,,
511th ,,	,,	,,
5th Aust. ,,	2nd Aust. Div.	,,
6th ,,	,,	,,
7th ,,	,,	E.
9th ,,	3rd Aust. Div.	D.
10th ,,	,,	N.E.
11th ,,	,,	,,
8th ,,	5th Aust. Div.	,,
14th ,,	,,	,,
15th ,,	,,	,,

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SIGNALS.

AVRE. 4TH APRIL, 1918.

Unit.	Formation.	Remarks.
Fourth Army Signal Co.		N.E.
T. Corps Signal Co.	XIX Corps	D.
3rd Signal Sqn.	3rd Cav. Div.	E.
14th Divl. Sig. Co.	XIX Corps	,,
18th ,,	,,	,,
24th ,,	,,	D.
58th ,,	,,	N.E.
2nd Aust. ,,	,,	,,
3rd Aust. ,,	,,	,,
5th Aust. ,,	,,	,,

ANCRE, 1918. 5TH APRIL, 1918.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
G Special (Projector) Co.	Special Bde.	E.
J. ,,	,,	,,
N. ,,	,,	,,
Q. ,,	,,	,,
132nd Army Troops Co.	VI Corps	D.
142nd ,,	IV ,,	N.E.
146th ,,	VII ,,	D. No diary.
147th ,,	IV ,,	,,
149th ,,	IV ,,	,,
221st ,,	VII ,,	N.E.
232nd ,,	VI ,,	,,
238th ,,	VII ,,	,,
280th ,,	V ,,	,,
559th ,,	V ,,	,,
565th ,,	VI ,,	,,
574th ,,	VII ,,	D. No diary.
577th ,,	V ,,	,, No diary.
7th R. Monmouth Army Troops Co.	IV ,,	,,
No. 1 Siege Co. R. Monmouth	VI ,,	N.E.
174th Tunnelling Co.	VI ,,	D.
175th ,,	V ,,	,, No diary.
177th ,,	VII & VI Corps	N.E.
178th ,,	VII Corps	D. No diary.
180th ,,	VII ,,	N.E.
181st ,,	VI ,,	,,
252nd ,,	IV ,,	D.
257th ,,	VI ,,	N.E.
2nd Aust. ,,	VII ,,	D.
N.Z. ,,	VI ,,	N.E.
No. 3 Pontoon Park	V ,,	,,
No. 1 Foreway Co.	IV ,,	E.
No. 2 ,,	VI ,,	N.E.
No. 3 ,,	V ,,	,,
IV CORPS.		
152nd Field Co.	37th Div.	E.
153rd ,,	,,	,,
154th ,,	,,	,,
427th ,,	42nd Div.	,,
428th ,,	,,	,,
429th ,,	,,	,,

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ANCRE, 1918. 5TH APRIL, 1918.

Unit.	Formation.	Remarks.
IV CORPS.		
457th Field Co.	62nd Div.	E.
460th ,,	,,	,,
461st ,,	,,	,,
1st N.Z. ,,	N.Z. Div.	,,
2nd ,,	,,	,,
3rd ,,	,,	,,
V CORPS.		
69th Field Co.	12th Div.	E.
70th ,,	,,	,,
87th ,,	,,	,,
77th ,,	17th Div.	,,
78th ,,	,,	,,
93rd ,,	,,	N.E.
123rd ,,	38th Div.	E.
124th ,,	,,	N.E.
151st ,,	,,	E.
517th ,,	47th Div.	,,
518th ,,	,,	,,
520th ,,	,,	,,
247th ,,	63rd Div.	,,
248th ,,	,,	,,
249th ,,	,,	,,
VI CORPS.		
55th Field Co.	Guards Div.	N.E.
75th ,,	,,	,,
76th ,,	,,	,,
206th ,,	32nd Div.	E.
218th ,,	,,	,,
219th ,,	,,	,,
VII CORPS.		
4th Aust. Field Co.	4th Aust. Div.	D.
12th ,,	,,	E.
13th ,,	,,	,,

SIGNALS.

ANCRE, 1918. 5TH APRIL, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.		N.E.
D. Corps Signal Co.	IV Corps	D.
37th Divl. Sig. Co.	,,	E.
42nd ,,	,,	,,
N.Z. ,,	,,	,,
O. Corps Signal Co.	V Corps	D.
12th Div. Sig. Co.	,,	E.
47th ,,	,,	,,
63rd ,,	,,	,,
F. Corps Signal Co.	VI Corps	N.E.
32nd Divl. Sig. Co.	,,	E.
G. Corps Signal Co.	VII Corps	N.E.
4th Aust. Divl. Sig. Co.	,,	E.

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VILLERS-BRETONNEUX. 24TH-25TH APRIL, 1918.

Unit.	Formation.	Remarks.
FOURTH ARMY.		
III CORPS.		
2nd Field Co.	8th Div.	E.
15th ,,	,,	,,
490th ,,	,,	,,
79th ,,	18th Div.	N.E.
80th ,,	,,	,,
92nd ,,	,,	,,
503rd ,,	58th Div.	E.
504th ,,	,,	N.E.
511th ,,	,,	D.
AUSTRALIAN CORPS.		
4th Aust. Field Co.	4th Aust. Div.	N.E.
12th ,,	,,	,,
13th ,,	,,	,,
8th ,,	5th Aust. Div.	,,
14th ,,	,,	,,
15th ,,	,,	,,

SIGNALS.

VILLERS-BRETONNEUX. 24TH-25TH APRIL, 1918.

Unit.	Formation.	Remarks.
Fourth Army Signal Co.		N.E.
C Corps Signal Co.	III Corps	,,
8th Div. Signal Co.	,,	E.
18th ,,	,,	N.E.
58th ,,	,,	D.
K Corps Signal Co.	Aust. Corps	N.E.
4th Aust. Divl. Sig. Co.	,,	,,
5th ,,	,,	D.

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DESCRIPTION OF WATER POWER PLANT FOR COUNTRY HOUSE LIGHTING.

By Captain A. R. Hildebrand, R.E.

The success which has attended the installation of a small water power plant for power and lighting purposes on a farm at Higham, Suffolk, has induced the author to write a description of it, with a view to showing that, where water power is available, a plant of this kind is quite practicable and useful.

The stream which has been harnessed is some 15 feet wide, and its normal depth is from 3 to 4 feet in the middle. Calculations made before any work was begun showed that during the summer months about 5 h.p. was available if all the water coming down were used. The maximum possible head which could be obtained without flooding above the site was 3ft. 6ins. The level of the stream is somewhat variable, depending on the operations of mills further up stream; and down stream, owing to weeds, there is a tendency to flood at certain times of the year. When this occurs there is no corresponding rise in the level of the head water, and the head available is sometimes reduced to 9 inches. During the four years in which the plant has been in use, the floods have never lasted for more than a week, and the head never remains at its minimum for more than 48 hours. These varying conditions are of importance as they have considerable bearing on the choice of design and of the capacity of the battery, as will be seen later.

The actual site available was that of an old linseed mill which had been destroyed by fire. The old mill-race was still intact, but the wheel itself and sluice-gates were gone. A sketch plan of the site is given, and it will be seen that the arrangement of the old mill was unusual. The original bed of the stream was used as a bye-pass, while the mill stream itself, after passing under the site of the old mill in a bricked tunnel, ran along an artificial channel and joined the bye-pass some 200 yards down stream. The sluice-gates were originally at the point of division of the bye-pass and the mill stream. From there the bye-pass ran down a narrow passage 15 feet long and 7 feet wide, with vertical brick sides and concrete bottom, and fell into a mill pond. This pond is some 20 yards in diameter, and in the centre, and where the stream falls into it, is nearly 14 feet deep. There were two possible positions for the turbine, (i) point A on sketch 1 where the old mill had been, with the sluice-gates in their original position, and (ii) point B, at the end of the passage mentioned above, with the outlet submerged in the deepest part of the pool.

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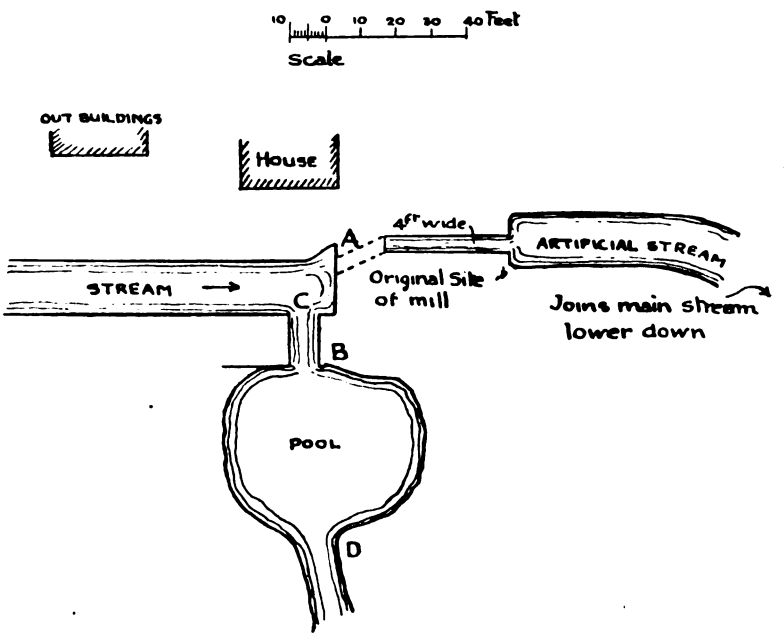
The disadvantage of the first position was that the narrow tunnel did not form a quick get-away for the tail water and that the bottle neck formed by this and the somewhat narrow artificial channel would have the effect of raising the level of the tail water, thereby reducing the available head. The only advantage in this position was that the water could be diverted into the pool, and that all construction work could be done in the dry.

The second position was therefore chosen as the large surface of the pool would reduce any tendency for the water to back up. The sluice gates were placed at the mouth of the tunnel where the old mill had been.

In order to be able to make the foundations for the turbine and to get the outlet pipe fixed in its proper position, it was necessary to drain the mill pond as far as possible. This was done by damming the stream at points C and D on sketch I, and pumping the water

Sketch I



out of the pond over the dam at D. The main stream was meanwhile diverted through the tunnel. Great difficulty was experienced in sufficiently reducing the level to allow the construction of the foundations to begin. Owing to leaky dams and the presence of either springs at the bottom of the pool, or leaks through the ground from the stream above, it was necessary to instal a power pump and keep it running continuously. Eventually after considerable delay, due to strikes and bad weather, the work was completed, and the position of the various parts of the plant are shown on sketch II.

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The grille, made of 1¼" flat iron with 1" waterway between each bar is to prevent weeds, which would soon do damage, from getting into the turbine. The drop gate above the weir, rests along the top of the concrete wall, and is used to head up the water an extra 6" if desired. The boom is so placed to prevent surface scum from going through the turbine.

Now as to the plant itself. Enquiries had been addressed to three firms who specialised in pump and turbine manufacture, asking them to give an approximate estimate for the manufacture of a 5 h.p. turbine to work at a head of 3 feet. The results were somewhat surprising. The first firm refused to give any estimate and said the cost of manufacture would be prohibitive. The second quoted between £400 and £450, and the third the surprisingly low figure, in view of the replies of the other firms, of £180. This offer was accepted, and they sent an expert down to look at the site, and in consultation with him the arrangement outlined above was decided on. The turbine is an in-flow-radial type, i.e., the inlet is round the circumference and the outlet at the bottom of the machine, and is designed to give 5 h.p. with a head of 3 feet. The driving shaft is vertical and its normal speed is 90 R.P.M. The only other working part of the turbine is the gate regulator which increases or decreases the apertures on the circumference, thereby regulating the amount of water flowing through the turbine. This is worked by another vertical shaft turned by means of a worm and wheel gearing.

On top of the driving shaft is a crown wheel and from this by means of a bevel drive, geared at 8 to 1, is driven a horizontal shaft. This shaft is coupled to the dynamo by means of a flexible coupling, and it is supported by two ringed oiled bearings. The small bevel wheel is made of compressed raw hide to reduce noise and vibration.

The controls, dynamo and battery, are placed in a wooden hut built on R.S.J's. across the passage, the vertical shaft of the turbine coming up through the floor. The bevel gearing is protected by a wooden box.

At first the turbine was run without any automatic speed control, but owing to the constantly varying head of water and varying loads which came on it, it was found necessary to fit a governor to control the inlet gates. Briefly the action of the governor is this. There are two drives from the horizontal shaft to the governor, one works the governor head, the other a small oil pump. The regulator is opened or closed by a double acting cylinder on the governor. If the speed falls below normal, the governor head opens a valve which admits oil under pressure to one side of the cylinder. The cylinder moves and in doing so opens the inlet gates of the turbine and allows more water to flow through, until the correct speed is attained. If the speed rises above normal, the oil is admitted to the other side of the cylinder, and so closes the gates. This form of governor has been

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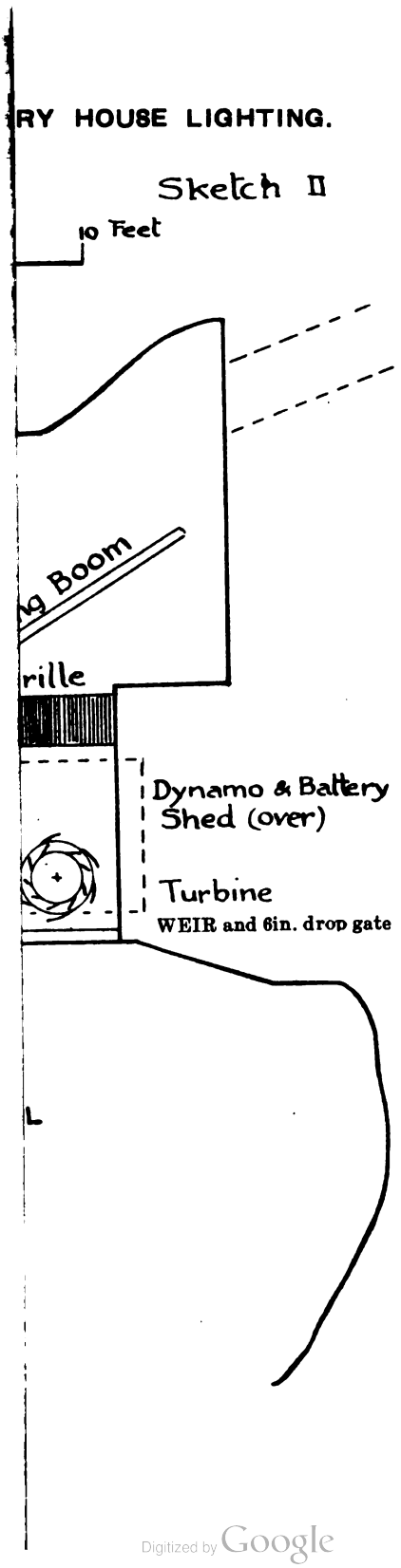
RY HOUSE LIGHTING.



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found to work quite satisfactorily, and the machine very quickly adjusts itself to any condition of load. There is a tendency to hunt when the turbine is first started up, but once it has settled down the machine can be left to run itself. The governor is not used when charging accumulators, as the turbine speed for this purpose has to be reduced below the minimum speed at which the governor is sensitive.

The dynamo is a compound-wound 220 v. 3 KW. Crompton machine, normal speed 700/800 revs. The compound winding is necessary to keep the voltage constant at varying conditions of load, since the speed is already kept constant, as described above. The chance of a simultaneous failure of the turbine and automatic cut-out, while charging, is very remote, and there is nothing to be feared in using a compound motor for this purpose.

The accumulators are 100 A.H. capacity and the house lighting voltage is 50, i.e., 27 cells in all, including end cells. The capacity was arranged so that in case of flood he lighting service can be maintained for one week without recharging.

At first an attempt was made to light the house direct off the dynamo at 220 volts, but owing to an irregularity in the crown wheel gearing, the voltage was not sufficiently steady to give direct light, and a battery had to be introduced. In any case it would have been necessary to carry over times of flood, when it is impossible to obtain sufficient speed to give the full voltage. Charging is done by removing the belts to the governor and running the dynamo slow. The normal charging rate is 10-12 amps., and even with the head as low as 9" it has been found possible to give the batteries a charge at 5 amps. By taking every available opportunity of a slight fall of water, it has always been possible to keep the batteries fully charged during floods.

The switchboard is of the usual type with field regulator, dynamo and battery voltmeter, an ammeter in the dynamo circuit, automatic cut-in and out with mercury contacts, charge and discharge switches for the end cells, a double throw switch for connecting the generator to the power circuit or to the battery, and finally, a single throw switch for disconnecting the house lighting circuit.

The house wiring is in two separate circuits, one for power at 220 v., the other for lights at 50 v.

The former is intended for the standard fitments such as kettles, irons, etc., and also for the various machines connected with the farm. On this circuit is run a circular saw, corn grinder, chaff cutting machines and root cutter, and a small electric laundry. Some control is necessary in the use of these machines to ensure that the plant is not overloaded, but this is a comparatively simple matter.

The lighting circuit consists of about 30 points and this includes lights in some of the farm buildings where required.

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The whole of the wiring is done with lead covered twin or 3-core wire in the house itself and the ordinary braided wire on cleats in the out buildings. Wires between buildings are overhead.

The total cost of the complete installation as described was £800. The running costs, apart from interest charges, are practically nil, and only amount to the cost of a few gallons of lubricating oil per annum. As there are no running costs to speak of, it is no extravagance to run the machine for the smallest load for 24 hours out of 24 if required.

If at any time it is found necessary to increase the amount of power available, it can very easily be done by either increasing the voltage or the capacity of the batteries, and charging during the night.

This plant has now been in use for over 4 years, and since the battery and governor were installed has given no trouble whatsoever. It is extremely simple to work, and anyone can be taught to start it up and stop it in a very few minutes. The battery has been given regular work and kept well charged and is in perfect condition. It is most important to keep weeds and solid matter from the inside of the turbine, but apart from that there is very little to go wrong. The only breakdown which has occurred since the plant was put in, was due to a nut dropping through the floor of the hut and becoming wedged in the turbine gate. When the gates, which are cast iron, were closed, one of them cracked and had to be replaced. A recurrence of this has been avoided by covering in the whole of the floor, so that nothing can drop through.

On the whole this plant has very decided advantages over a paraffin plant of the same H.P. and up to the present has proved itself quite as reliable and useful, and the possibilities of installing a similar set where water with even very low heads is available, should be carefully explored.

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DDITIONS AND CORRECTIONS TO BATTLE HONOURS OF R.E. UNITS.—*R.E. JOURNAL, DECEMBER*, 1925.

age 633. *Mount Sorrel.*
The last date of this battle was 13th June and not 15th.

age 635. *Albert*, 1916.
For 233rd Field Co. of 31st Div. read 223rd.

age 637. *Bazentin.*
Strike out IIA. Corps Signal Co. and IV A. Corps Signal Co. as the II and IV Army Corps were not engaged in this battle.

age 638. *Delville Wood.*

Add after 7th Divn.	61st Field Co.	14th Div.	E.
	62nd ,, ,,	,,	E.
	89th ,, ,,	,,	E.
	14th Divl. Signal Co.	,,	D.
	77th Field Co.	17th Div.	E.
	78th ,, ,,	,,	D.
	93rd ,, ,,	,,	E.
	17th Divl. Signal Co.	,,	D.
	XIII Corps Signal Co.	XIII Corps	N.E.
	XIV ,, ,, ,,	XIV ,,	N.E
	XV ,, ,, ,,	XV ,,	N.E.

Page 639. *Pozieres.*

	Add X Corps Signal Co.	X Corps	D.

Page 641. *Guillemont.*
Line 35 after 24th Divn. for 5th Div. read 55th Div.

	Add XIV Corps Signal Co.	XIV Corps.	N.E.
	XV ,, ,, ,,	XV Corps.	N.E.

Page 642. *Ginchy.*

	Add XIV Corps Signal Co.	XIV Corps.	N.E.
	XV ,, ,, ,,	XV Corps.	N.E.

In the *R.E. Journal*, June, 1925, page 24. The last day of the Battle of the Aisne is 12th September, 1914, not 15th.

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out early and gradually improved. Short cuts across the grass should be forbidden, and all transport should be *strictly* confined to the roads or to selected parking grounds. It is particularly necessary to watch this in the early stages, or the transport bringing the tents, &c., to the site may spoil the surface irretrievably.

In an ordinary camp it is usual to cook in the open, but in a standing camp cover should be provided over the cooking stoves, and also over some place for preparing and issuing food. A store is also required for meat and bread, which must be made fly-proof. The floors of these shelters should be of concrete, graded to a foul drain. As concrete floors take time to set and troops are always impatient to occupy their camps, we started a slab factory on the site of each camp, where we made up concrete slabs about 2ft. x 2ft. x 2½in. thick. These were given plenty of time to harden, and can then be laid in a few hours and are easily replaced if broken or worn. They can also be used for floors of ablution and bath rooms, and possibly for latrines.

Wherever possible we arranged a bathing establishment on the same lines as described for hired buildings, using for this purpose some neighbouring building or barn.

Accommodation for Prisoners of War.

If the work we did on hired buildings was that which gave us the most satisfaction, the work on prisoners' camps was the most troublesome. In March, 1915, the only prisoners' camp in the command was at Stratford (atte Bowe) in the east of London. It was an old building, such as can be met with in hundreds in London, used for general manufacture. It was large enough to provide sleeping space for 900 prisoners, but the only open ground near it was a small yard enclosed by a wire fence. The whole building was surrounded by small workmen's houses, and this was perhaps its greatest safety, as the occupants of these houses who had relatives and friends at the front, used to express their opinion of the Germans in very plain language. After the first gas attack outside Ypres the prisoners asked for permission to do without their usual exercise, as they were afraid of violence from their neighbours! Over £6,000 was spent on structural alterations to make this building habitable.

My next experience was with the Alexandra Palace. This pleasure house of iron and glass had been occupied by parties of refugees from Belgium, and, when better accommodation was found for these, was taken over for prisoners. Our first instructions, received through the General Staff of the Command, were that the Palace would hold 5,000 prisoners and would be required in a week. I at once visited the building and discussed details with the Commandant and with the D.O.R.E. The nature of the buildings made the problem

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somewhat unusual, as the glass sides allowed of a forced exit at almost any point, while the floors were open battens and the whole building was a nest of rooms and passages. Also in the building itself there were practically no facilities for cooking, and almost all the latrines provided for the public were outside the building. However, there was a roof and water, and drains were within reach.

For the walls of the building my D.O. made an excellent suggestion, which was to line the whole building to a height of about

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camp to take 5,000 prisoners had been constructed by the Office of Works, and that they required assistance in arranging the wire enclosure surrounding the camp. Here again I found the original camp had been formed for refugees, who had been allowed to construct their own shelters. There was originally a small house and a few buildings on the site, but no facilities for water or drainage. The place was some way from the nearest railway station.

The shelters erected by the refugees were supposed to accommodate 1,000 in all; they mostly consisted of small shanties about

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For the walls of the building my D.O. made an excellent suggestion, which was to line the whole building to a height of about 9 feet with expanded metal as used for reinforced concrete. This did not interfere with light or air, but is a good obstacle, as it is very difficult to cut and very uncomfortable to climb.

For cooking we had to provide an entire new outfit, as the Belgian refugees had only been supplied with very meagre apparatus. For ablution and latrines we had to form enclosures inside the building, and lay drains and water, the floor being formed of patent flooring material laid straight on to the boards. Baths were also provided.

The layout of the building presented some difficulty, and it was evident that the number who could be accommodated had been overstated, but later, by making some structural alterations, we accommodated the full 5,000. In order to fit beds into a large area like this, with no walls on which clothes could be hung, we made dwarf walls of wood about 3 feet high and about 15 feet apart, running the length of the building. Beds were then arranged head to wall on each side, and the clothes were arranged on a shelf on the top of the wall. At the same time the sentry had an uninterrupted view of the whole space. Each group of a thousand men was formed into a unit under its own leader, and each group had its own dining-room and accessory buildings. As the occupants were Germans domiciled in this country they were presumably friendly, and were allowed some privileges, such as access to the Concert Hall, where they gave excellent performances. For the purpose of exercise we formed areas in the grounds, one for each group of 1,000. The staff of the camp was accommodated in a wing of the building. The military guard was in huts in the grounds. It took us three weeks of hard work before the prison could be occupied, even in part.

The third big prisoners' camp we had to do with was near Weedon. The first we heard of it was a letter from the War Office stating that a camp to take 5,000 prisoners had been constructed by the Office of Works, and that they required assistance in arranging the wire enclosure surrounding the camp. Here again I found the original camp had been formed for refugees, who had been allowed to construct their own shelters. There was originally a small house and a few buildings on the site, but no facilities for water or drainage. The place was some way from the nearest railway station.

The shelters erected by the refugees were supposed to accommodate 1,000 in all; they mostly consisted of small shanties about

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8 feet wide, with a double tier of bunks down each side. The floor space was less than 10 feet per head and the lighting and ventilation were defective. There was one good hall, with a wooden truss roof, which was used for dining. On to this very inadequate nucleus the Office of Works had added a new camp for 4,000 men. I gathered that the Office of Works, who in times of peace are responsible for the "works" connected with all Government establishments, and who have a very efficient staff of engineers and surveyors, had represented to the Government that they might be able to help in the execution of some of the heavy programme of engineering work. They were thereupon put in charge of this prisoners' camp for 4,000 men, and proceeded to lay it out and erect huts and accessories, without any reference to the Command, and apparently without reference to the W.O. scale of accommodation in hutments. The latter is important, as prisoners of war are supposed to receive the same facilities as regards floor space, light, air and water as are given to our own men under war conditions. The results of the work were very much what was to be expected under the circumstances. All the engineering work was excellent; the huts were well constructed, an elaborate system of water supply, with a specially sunk well, was provided, a new sewage plant was constructed on the sprinkler system, and an electric power station for light. On the other hand, the accommodation in the sleeping huts was on a scale of 30 feet floor space only; the whole lay-out was very cramped, the huts were too close together and too near the boundary of the site, and there was no hospital accommodation, except a small house which had been used for the refugees, which contained beds for seven men only. The latter was about enough for the sick of the guard detachment, but much too small for the prisoners.

On reference to the War Office it was decided that as the huts were of a large size with high roofs, the 30-feet floor space could stand, but the original nucleus of refugee shanties was abolished altogether. A hospital for about 50 beds was provided in huts inside an enclosure. Additional accommodation was provided for the guard and a barbed wire enclosure added round the main camp, with sentry posts. The camp was then taken into use, but was rather troublesome to work, as everything and everybody had to be carried by road transport from the nearest town, which was some miles away.

In addition to these three camps, we had to prepare a large house near Uxbridge as a prison for officers, which gave a lot of trouble, and also had to enclose a large hospital near Dartford for sick prisoners. When home-grown timber began to be cut systematically, several small camps for small parties of German prisoners were formed in different localities. These gave no trouble. We also prepared Feltham Detention Institution to accommodate prisoners from friendly countries who had been compelled to fight against us.

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The form of the obstruction round these camps requires a short notice. The obstacle surrounding such a camp has got to be capable of keeping out communication from outside, as well as of keeping prisoners in, and if the prisoners try to force a way out the obstacle must detain them sufficiently long to give the sentries time to use their rifles. The best form of obstacle is, therefore, two lines of vertical fence, each about 5 feet high and set 6 feet apart. This centre gangway should be kept perfectly clear and must be commanded by sentry posts at intervals, which should if possible be raised above the ground. Inside and outside these fences there should be an apron of loose coils of wire about 5 to 8 feet wide. The fence must be illuminated at night throughout its whole length, and the neighbourhood of the prisoners' huts and the ground inside the enclosure must also be sufficiently illuminated to enable any movement to be detected.

Miscellaneous.

In addition to the accommodation for men, there were a large mass of miscellaneous services which can only be indicated.

Churches. At first no provision was made for religious services in any of the hutments, but later, in the middle of 1915, the War Office approved of the allotment of one 60-feet hut in each Brigade camp as a chapel and office for the Church of England padre, and of one hut each in a divisional camp for the Roman Catholics and Presbyterians. These huts were fitted up by voluntary effort and were much appreciated.

Barrack Stores. Two huts in each brigade lines were allotted to the Barrack officer, and the space between enclosed as a yard for heavy stores and cases. These answered fairly well, but it would have been better to provide a special establishment in the first place, situated near a main road and with proper unloading space for lorries.

Horse Lines and Veterinary Hospitals. Horse lines were provided in the original hutments for the 1st line transport of the units, but were practically hardly ever used. When the hutments were used for Reserve brigades, the horse lines were converted into drill sheds, by knocking out the insides as far as possible. We had also in the command a number of horse depots, of which the most important were at Northampton, Kettering, and Puckley, in Kent. In most cases we had to improve the accommodation for attendants. The question of flooring gave some trouble, as the supply of bedding gave out, so that horses had to stand on a hard floor. As a rule, concrete makes a bad stable floor, unless it has plenty of time to harden, and bricks on edge are a better substitute. Watering places

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must be surrounded by a hard, well-drained surface, or there will be trouble with mud. Drainage wants a good deal of attention.

Pay and Record Offices. These offices grew enormously during the war, and special arrangements were made for their accommodation. They not only kept the accounts of the troops themselves, but had to deal with a mass of correspondence with wives and other dependants; they were staffed very largely by women. At first these offices started in barracks and military buildings, but as they increased in size, extra buildings were required. I found the R.E. Record Office was occupying nearly a quarter of Brompton Barracks, while the Pay office was using about 70 different dwelling houses in Rochester.

The first change we made was at Hounslow, the Headquarters of the Home Counties group of units, where my D.O., Major Chapman, S.R.E.S., suggested that an office of large huts should be constructed at one side of the parade in the barracks. We obtained War Office approval to the erection of two large huts, each 150 ft. by 30 ft., to accommodate 100 clerks in each, and these proved so successful that the number was increased up to 10 huts, accommodating about 1,000 clerks in all. The 28-ft. sectional hut was used for the extension. These huts were arranged parallel to one another with a central corridor down the middle. Cloak rooms were arranged off this corridor and latrines for women clerks were put at one end. In the centre of each hut was put the supervisor's room, which was screened by a glazed partition. Each end of the hut accommodated 50 clerks. Emergency doors were arranged at each end for exit in case of fire. I designed a special form of desk on the knee-hole principle, but these were not liked, as the officers preferred to use the ordinary trestle table, and to keep all papers above the table. This scheme was so successful that we applied the same principle to other offices. A large office was constructed on the Black Lion field on Chatham Lines for the R.E., also one at Warley for the East Anglian units, at Dover for R.G.A., and at Woolwich we had three offices for R.F.A. and A.S.C. Two of these were in existing buildings expanded by huts. One was in a new hut office on Woolwich Common. I believe the War Office adopted our arrangement for other commands.

Ordnance Buildings. The ordnance stores in the Command all required some additional accommodation, notably at Dover. At the Weedon depot we were told to provide accommodation for 1½ million rifles which were being supplied. The W.O. scheme was to stack the rifles on their sides in stacks which could not exceed 6 feet in height. The building selected was a high one, and in order to get more floor space it was proposed to erect a wide gallery all round the walls. On going into details as to space round stacks, we found it

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advisable to construct a complete upper storey of steel and concrete, and this was really easier to construct than a gallery. A large lift capable of carrying considerable weight was constructed between the two floors. In addition we had to carry out a scheme for the extension of existing buildings and sidings.

Schools, &c. Among miscellaneous jobs which may be mentioned was the conversion of houses into schools, both for our own Command and the London District, and the conversion of hutted camps into convalescent depots, the latter requiring the provision of massage accommodation and an extension of recreation and lecture rooms. A very successful convalescent camp was formed at Eastbourne, and both Seaford and Shoreham hutments were similarly used.

Rest Camps at Folkestone. This was the principal port of embarkation and disembarkation for the Army in France. As the train movements did not always fit the boats, there were always a number of men in Folkestone at a loose end. When bad weather prevented the boats from starting, the number grew very large. During the winter of 1914-15, accommodation was found for such men in the local drill halls and at Shorncliffe barracks. But with the occupation of these barracks by Canadians, and with the increased numbers travelling, the accommodation proved inadequate, and at the beginning of the winter of 1915-16, the War Office decided to form a Rest Camp near the harbour. House valuers were sent down from the War Office, who selected two streets, totalling 30 houses, and warned the occupants to turn out, bag and baggage, at 7 days' notice. The scheme was then turned over to us, and we were told to provide a minimum of cooking and ablution accommodation and to enclose the area. As these houses had no gardens, we took over the road in front of the houses and erected a temporary cookhouse and ablution rooms on the road. Drains and water were available, and we had some sort of an establishment ready in three or four days. At first we fenced the area with barbed wire, but later erected a close galvanised iron fence about 7 feet high, entirely cutting off the view from outside. The establishment of this camp undoubtedly caused much inconvenience to some individuals, but under the circumstances, it was the only solution of the difficulty. I never understood, however, why the construction of a rest camp was deferred to the second winter of the war, as it seemed such an obvious necessity at a port of embarkation.

Later on, a second rest camp was formed at Folkestone, from another group of houses a little further away from the pier.

Richborough. The now well-known port of Richborough, though situated in our Command, did not give much work to our staff. When it was first suggested in 1916, I accompanied Major General

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Scott-Moncrieff on a visit to the site with Captain Collard, who was one of the originators of the scheme. The question of accommodation was discussed, and it was suggested that as the staff of the Port would be mainly Engineers, and as they would be doing a good deal of engineering work in constructing the wharf, they might be allowed to build their own huts. As we had at the time plenty of work on hand in that part of the country, I was glad to accept the offer of help. At the same time General Scott-Moncrieff asked me if he could take away Mr. Allen Williams, then acting as my Division Officer at Shoreham, to take charge at Richborough. At the end of 1917, when I was D.D. Works in France, I visited Richborough in connection with the large transport of engineer stores to France, and found Brig. General Allen Williams commanding an establishment which had grown to a total of 14,000 all ranks!

Mechanical Transport Depot. The last job which calls for comment in this part of these notes is the Mechanical Transport depot at Kempton Park, which was started in 1916. This was a scheme prepared at the War Office, and the site was taken over and work commenced before the Command was told anything about it. I visited the site as soon as I heard of it, with my C.R.E. from Hounslow, Colonel G. Savage (late R.E.), and found it was proposed to form a large depot for the assembly and completion of new mechanical transport vehicles. The chassis for these were being made by contract in the United States, and were being landed at Avonmouth, whence they were to come to the depot by road; the bodies and other parts were made in England and came by train and road. When the bodies were put on, the vehicles had to be completed with tools, spare parts, water and petrol, tried on the road, and despatched overseas, generally through the port of Avonmouth.

The site selected for these operations was the racecourse at Kempton Park, which had a large expanse of grass, the usual grand stand and a few buildings, such as refreshment rooms and latrines for the use of the public. It was on clay soil near the Thames, with a nearly flat site.

We had establishments on racecourses at Epsom, Kempton, Brighton, Newmarket and Headcorn, and in each case when we took over a racecourse, it was coupled with the condition that the course itself was to be protected as far as possible. This condition makes the centre of the course a sort of island, and though we made boarded tracks across the racecourse itself, it was never possible to put buildings in the centre or to extend water and drainage to this area. The available ground for development was then restricted to the comparatively narrow strip containing the stands and enclosures. Also the stand itself is usually rather lightly built, and its construction, in a series of large steps, made it inconvenient

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for any purpose, unless the whole of the staging is removed and the building reduced to a roof with supports.

Knowing these disadvantages, as soon as I had ascertained the purpose for which the establishment was to be used, I departed from our usual practice and suggested to the M.G. i/c A. that before going further a report should be made to the War Office. This was done, but we got a reply that the selection of the site was settled and could not be altered. So we had to make the best of a bad job.

The principal requirement of a depot of this sort is covered workshop accommodation, with a hard floor on which the vehicles can stand, with inspection pits at intervals and arrangements for storing spare parts, &c., conveniently situated for the workshops. The grand stand was enclosed and made into a store. For the workshops Col. Cleeve, A.D.F.W., was able to produce from another Command a quantity of curved roofing sheets and iron supports, and by putting the latter on concrete legs about 3 feet high, we were able to obtain sufficient head room. With this we roofed the whole of the public enclosure next the grand stand. For flooring, we obtained the assistance of Mr. Maybury, who himself visited the site and arranged to supply tarred macadam for the floor, though this took nearly three months to finish. As it was obvious that any attempt to cover more grass surface would require a long time, we took over a length of new road close to the entrance of the park. This road was nearly a mile in length, and of a width to allow two lines of traffic in the centre and two lines of cars in sheds down each side. The surface was in good order and made a fairly good floor, and we constructed a line of shedding on each side. Even with this covered accommodation a very large number of cars in all stages of completion had to be parked in the open on the grass, and as winter approached these sank into the ground up to their axles. I believe that after I had left the Command it was necessary to keep two heavy lorries constantly at work dragging these new cars out of the mud.

Many of the workmen lived in the neighbouring houses, but we had to provide huts for a number of A.S.C., about 300 in all, on the site. The refreshment buildings were of some use as dining rooms and kitchens, and also the latrines, but we had to lay a complete drainage scheme to the nearest main drain, about 200 yards away, and also to lay a new water main of increased size. In short, we had as much work and expense as if we had started an entirely new establishment on a new site.

Work for and in Conjunction with the Medical Authorities.

Hospitals.

Although left to the last, the provision of hospital accommodation for our own sick and for the sick and wounded from overseas was not the least of our duties. It was certainly one to which I personally

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attached great importance, and to which I gave a good deal of my time. The first problem of the kind was brought to my notice a few days after I arrived in the Command by a visit to my office by the D.D.M.S., who said he had been sent by the M.G.A. to discuss a very important letter just received from the War Office. This was to the effect that the hospital accommodation for wounded men was insufficient for the numbers coming from France, and that immediate steps should be taken to increase the number of beds in the Command. The question was to be treated as very urgent. At first the D.D.M.S. seemed to think that the R.E. might raise difficulties, but I soon disabused him of this idea, and we settled down to a real discussion of the problem. It was evident that no individual building we could get hold of would meet the case, while the work involved in starting an entirely new hospital would take some time. All the military hospitals in the Command were full and were being expanded as fast as possible. None of the new hutments were sufficiently advanced to accommodate wounded. Tents were ruled out by the time of year—March, 1915. The only remaining alternative was the use of an existing barrack, which was pressed for by the D.D.M.S. On considering the available barracks in the command, it was evident that the nearer we could get to Folkestone the less distance would have to be covered by the wounded on arrival. There was already at Shorncliffe a good military hospital, and it happened that the nearest barrack to the hospital was built of one storey huts—brick with felt roof—probably erected in one of our little wars. It was therefore readily convertible. We put the proposal to the M.G.A., who approved of work going on at once and reported to the War Office the action we were taking. I communicated at once with my C.R.E. at Dover—Col. Littledale, R.E.—who I knew had had much experience of hospitals, told him what we wanted to do, and gave him instructions to go ahead and send us in a scheme, but meanwhile to start work on preliminaries. A few days later we got a reply from the War Office saying that General Scott-Moncrieff would visit Shorncliffe and inspect our scheme. I gathered later that the War Office had not expected we would use a barracks, but when I explained the circumstances to General Scott-Moncrieff, he not only agreed with our conclusion, but on visiting the site found very little to criticise in the details. He asked me, however, to keep him personally posted in any large scheme of this sort we might start, and this we did in future.

The next hospital scheme I had to deal with was at Brighton, where a large group of hospitals had been formed for the use of Indian troops, after the first hospital for native troops, formed in the New Forest, had proved too small for their requirements. The buildings used were the workhouse, re-named the Kitchener Hospital, and the historic buildings known as the Pavilion and Dome, near

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the front. These buildings were taken over at first by one of the leading Civil Surgeons and the work of adapting them was carried out by the town Surveyor. After the work was completed and the hospitals in use, we got instructions from the War Office that the Chief Engineer was to certify that the work was satisfactory and the expenditure reasonable. As the total sum involved was over £40,000, this was rather a large order. Fortunately it proved less difficult than appeared at first sight, as the work had been very well done. The accommodation provided was for about 2,000 beds, so that the expenditure was only £20 a bed, against £80 for a new hutment. We found, however, we had to add to the arrangements in several directions. The female nursing staff was badly housed, extra lifts and a second operating theatre were required in the workhouse building, and later, when the Pavilion was made a special hospital for the final treatment of men who had lost a limb, we erected workshops and other buildings in the grounds.

Another hospital which may be mentioned was at Cambridge, on a College cricket ground, where a hut hospital had been constructed under the supervision of a local doctor, who made a speciality of open air treatment. All the huts were built with one side open to the air both summer and winter. The results, as far as the treatment of sick and wounded was concerned, were quite satisfactory, but the treatment involved some hardship on the nursing staff in cold winter weather. The hospital lasted into the winter of 1915-16, when questions were asked in Parliament, and we were ordered to enclose the open sides of the huts with glass panels.

These three are only samples of the hospital work which came to hand at once, and as soon as I had got the main hutting work organised we began considering the question of more hospitals. As far as I could ascertain, on the outbreak of war the War Office policy was limited to the increased use of all military hospitals and to the taking over of certain buildings in defended ports, in accordance with the provisions of the defence scheme. In addition, the Central Force took over a number of buildings all over the Command as hospitals for their own troops, and when hutments were erected, a hospital was included in the scheme. At first all these hospitals were intended mainly for the sick of the Home troops, and it seems to have been thought that the wounded of the Expeditionary Force could be adequately dealt with in the existing military hospitals such as Netley, Millbank, or the Herbert Hospital, Woolwich, and in the Civil hospitals of the country. As soon as the probable scope of the war began to be understood, a special effort was made to increase the accommodation for wounded. In many places, like Cambridge, local hospitals were constructed under some special surgeon, in other cases individuals turned their own houses into hospitals and organised a staff of voluntary workers. Most of these were useful,

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some excellent, but there was evident some want of co-ordination, as all the hospitals were not readily accessible, and many of them were obviously too small to be worked economically.

After full discussion with the D.D.M.S. and M.G.A. we evolved a scheme for future hospital development in our Command on the following lines :—

1. The construction of a number of large hospitals within easy train journey of the ports of disembarkation.

2. The adoption of a large unit, 2,000 beds, as the minimum which could be economically administered.

3. The erection of such hospitals in the vicinity of towns of some size which would provide facilities for supplies, transport and accommodation for voluntary workers, and also systems of water, gas and electric light which could be of use for the hospitals.

As regards the last point, all the towns on the east coast of the Command were already occupied by defence troops and were within range of attack from the air, but along our south coast west of Folkestone there were very few troops except at Brighton, and this stretch of coast includes some of the best seaside resorts in England, which are well known for their healthy air and amount of sunshine.

A proposal was therefore put to the War Office that future extensions of hospital accommodation in our Command should be concentrated on the construction of hut hospitals for 2,000 to 4,000 beds each, to a total of 30,000 or 40,000 in all, in the towns on the south coast of Sussex. This proposal was accepted in principle, and we were told to put forward definite schemes. I then arranged with the D.D.M.S. to send one of his officers with Lt. Etherington to visit all the coast towns from Hastings westwards, to interview the local authorities and select sites. In the course of three days this deputation visited Hastings, St. Leonards, Bexhill, Eastbourne, Worthing, Littlehampton and Bognor, and in each place found one or two good sites which fulfilled our requirements. We were therefore able to put definite schemes to the War Office for the accommomodation of 36,000 men. The cost of hut hospitals at this time was about £80 a bed, so the total scheme would have cost three million pounds.

After sending in the scheme we heard nothing for some time, and on making enquiry at the War Office we gathered that difficulties had arisen, and finally all the schemes were dropped, much to my disappointment.

Meanwhile, the War Office had been in communication with the Metropolitan Asylums Board and with the Education authorities with a view to the occupation of some of their buildings as hospitals. The M.A.B. control a number of excellent establishments for the accommodation of pauper lunatics. By boarding out the quiet cases and concentrating the remainder, they were able to vacate

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several establishments, of which four were in our command. The two with which I had most to do were the Graylingwell Asylum at Chichester and the Horton Asylum at Epsom. The arrangements were very similar in both cases, the main building consisting of a series of two-storeyed pavilions, with large rooms connected by large wide corridors. There were also good administrative offices and cooking and dining accommodation, while in each case the buildings were surrounded by well-kept grounds. The superintendent of each Asylum, who was of course a medical officer, was retained in charge of the hospital, and also most of the staffs. By putting beds in the corridors, each building provided accommodation for about 2,500 beds, instead of the usual occupation of 800 to 1,000 patients. The engineer services required were mainly in connection with the accommodation for the female nursing staff, the provision of operating rooms (usually two) and some additions to the cooking apparatus. These involved an expenditure of £4,000 or £5,000 at each hospital. The proximity of the hospitals to small towns was of advantage in facilitating the service of the hospital, and the towns also provided a number of voluntary workers, who were of great service in many capacities. Altogether these buildings were an undoubted success.

The educational authorities were also able to give up a number of school buildings. These, if large enough, make good groups of wards, but a good deal of work is required to provide sanitary annexes, an operating room, and cooking and dining accommodation. Another difficulty was that, as only a proportion of the schools could be surrendered in any locality, this scheme involved the opening of a number of rather small hospitals scattered all over the Command.

In addition to hospitals run by the Command, we were often asked to advise on questions of drainage and fencing and similar details for hospitals erected by the Colonial Governments for their own men.

Before concluding this section a few words may be added on the adaptation of country houses for hospitals. Such houses generally have the advantage of being situated in private parks, which give excellent recreation space for convalescent patients, but there the advantage ends. The water supply and lighting are usually limited, the drainage out of date, while even in the largest houses, the rooms are comparatively small, and only a very small number of patients can be put into each room. Added to this there are a good many stairs, and no lifts capable of dealing with stretcher cases.

We had an example of this at Addington Park, near Croydon, formerly the residence of the Archbishop of Canterbury. This was an old house with beautifully panelled walls, and fitted with marble fireplaces and several large old-fashioned glass chandeliers.

When I first saw it, it had been occupied for some months, and it had been found necessary to close the front staircase altogether,

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to board up all the marble fire-places, and to enclose the chandeliers in large cages of wire netting. Finally we decided to use the house itself for administrative offices and for officers' cases, and to erect wooden huts for ordinary cases, and later a convalescent hut camp was erected in the grounds. This involved the laying of a new water main from the Croydon system and the construction of a new drainage system.

By the end of 1915, we found we had in our area over 65,000 hospital beds administered directly by the Command, besides many voluntary hospitals.

During 1916, although we did not open many new hospitals, there was a continuous growth in the number of beds, due to urgent demands from the War Office following each phase of the operations overseas.

The nett result of our experience, as it was impressed on my mind at the time, is that the best hospitals, with the possible exceptions of the M.A.B. buildings, were the newly-constructed hut hospitals, built on a large scale on carefully-selected sites. Such hospitals being all on one floor, the movement of the occupants is easy, not only as stretcher cases, but also when convalescent. Two-storey buildings require lifts, and lifts to take stretcher cases are not often available.

For constructing hut hospitals the allowance of floor space was usually 60 feet per bed, with 6 feet of wall space. At first hospital huts were built to a width of 24 feet, but later Col. Armstrong got out a design for an 18-feet hut, which is about the minimum width which should be used. Later he got out a 100 bed ward with four rows of beds, but this seemed to me rather cramped, though much more comfortable that a tent hospital.

The arrangements of the hospitals followed the normal design of permanent military hospitals, except that a much larger proportion of the space was allotted to surgical cases, involving additional operating rooms and careful grading of corridors.

The increase in the female staffs, not only for nursing but for cleaning and cooking, required special arrangements, such as a special cloakroom and latrine accommodation, for the staff which came to work daily, while the nursing staff, who had to sleep in, were given accommodation similar to that provided for officers in hutted camps.

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DEMOLITION OF TREE STUMPS.

By LIEUT. T. I. LLOYD, R.E.

In the training of troops in the use of explosives it is as well if the work done can be of use to someone. A good opportunity for this was afforded in Belfast recently, and since a similar opportunity is liable to occur at many another station, a short account of the work done and a certain amount of data collected, follows.

A new golf course was in course of construction some six miles from the city, and with the consent of the club we were allowed to do our training there.

There were trees of all sizes which had to be felled, and it was these that we attacked.

On a golf course a tree stump is a nuisance less only than the whole tree, and so we decided to remove stumps and all if possible.

The blowing of a small mined charge under the centre of the tree was satisfactory. The larger roots on the side of the tree in the required direction of fall were first cut by axe, and, when the charge was fired, the tree fell into the crater, overbalanced, and crashed to the ground pulling out the roots on the far side.

This method was employed with complete success for several trees, but was given up for two reasons :—

(*a*) The direction of fall could not be guaranteed and the tree was liable to get entangled with others near by.

(*b*) The trunk was generally split.

The merchant who bought the timber objected to (*b*), so we let him fell the trees and ourselves tackled the stumps, for which the small mined charge was completely successful.

To place the charge, the turf was removed from around the tree and the most suitable spot for burrowing selected. To make the burrow, a crowbar was found the most useful tool, and since the burrow never had to be longer than a man's arm, no difficulties were met. In the case of a large tree with tangled roots, a primary charge was sometimes fired to help the burrowing.

The explosives used were ammonal and guncotton. The ammonal charges were made up in small bags, and were easier to place and more satisfactory than the slabs of guncotton. Tamping of wet clay, well rammed, completely filling the burrow, and heaped to a height of about two feet, was satisfactory.

The effect of firing the charge was to split the stump into three or four fragments, which were hurled a few feet, leaving a neat shallow crater.

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This method of dealing with stumps shows a great saving in time and labour on the normal method of digging and jacking them out. The foreman in charge of the construction of the golf course was most enthusiastic about it. He had had experience of splitting stumps with charges in auger holes—our method was more satisfactory.

The supply of primers gave out, but we had plenty of No. 8 detonators. Two detonators tied together never failed to detonate an ammonal charge. To detonate a two-slab charge of guncotton after the primers had all been used, it was necessary to employ a half-pound charge of ammonal tied to the slabs and detonated as above. A smaller amount of ammonal only smashed the guncotton. When this happened we were able to collect the fragments and with them make up a charge which was successfully detonated with a half-pound charge of ammonal.

Both the electrical and the safety fuse methods of firing were used. Every man was given his turn at making up and placing a charge. The training was considered satisfactory, and although only a small proportion of the total number of stumps on the course were dealt with, the committee of the club were very grateful.

Taking the average, three men demolished a stump in two hours.

As a stump is weak against vertical shear, it is important that the charge should be under the very centre of the bole. A charge not so placed will hurl the portion of the stump immediately above it a considerable distance, leaving the remainder of the stump in the ground.

Too heavy a charge throws a lot of debris into the air. The following table gives charges which will do the work satisfactorily with a minimum throw of debris :—

Diam. of tree or stump at height of 2ft.	Weight of charge. Pounds.
0″——17″	1
18″——23″	1½
24″——27″	2
28″——31″	2½
32″——35″	3
36″——42″	3½

The table is for all the common species of trees in clay soil. The charge should be no deeper than necessary.

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AN UNOFFICIAL HISTORY OF THE SIGNAL SERVICE WITH THE BRITISH SALONIKA FORCE, 1915-18.

By CAPTAIN C. C. S. WHITE, M.B.E., R.E.

A campaign that has had very little written about it, is that of the British Army in Salonika, 1915-18. The reasons why this campaign did not become "spectacular" until September, 1918, are many and beyond the scope of this article to propound. It is sufficient to say that the British and French troops arrived in Salonika about three months too late to rescue the Serbs from a combined attack of the Austro-German and Bulgarian Armies, due to the delays of diplomatic and military "pour-parlers." Bulgaria, after nine months' vacillation, mobilised on September 23rd, 1915. The following day Greece followed suit. Serbia, who had so far resisted the Austrian attack on her northern frontier with success, saw that her only hope lay in attacking Bulgaria immediately, before the latter had completed her mobilization, and so appealed to the Powers of the Entente to sanction an immediate assault on Bulgaria. This appeal was supported by the Greek Government, who were pledged by the Treaty of Bucharest to assist Serbia in the event of her being attacked by Bulgaria.

At first this was not permitted, but it soon became evident that Bulgaria, in conjunction with Austro-German forces then being made ready, evidently intended to attack Serbia. So the question of sending troops to the aid of Serbia was once again considered. Greece alone was in a position to help. A condition of her intervention was that she should be reinforced by 150,000 Entente troops, and as an encouragement to her to take action, one British and one French Division were ordered to Salonika from Gallipoli. While they were on their way the position at Athens was revolutionized. On October 5th, 1915, King Constantine had driven M. Venizelos from office by a flagrant violation of the constitution, and had definitely repudiated his treaty obligation to assist Serbia. Not only did he decline to intervene but he did everything in his power to hamper our movements. On arrival at Salonika, the first Entente troops were allotted 15 metres of quayside for their disembarkation. This situation, of being confronted with a pro-German Greece instead of an ally, proved a very serious menace to our base and lines of communication. It had its effect on all our subsequent operations in Macedonia until May, 1917, when King Constantine was forced to abdicate and the Greek Army came to our assistance with a final total of 200,000 men in 1918.

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SERBIA, 1915.

At the very moment when our first troops, the 29th Brigade of the 10th (Irish) Division, were landing in Salonika, October 5th, 1915, the Bulgars, who had completed their mobilization, crossed the Serbian frontier. By the time the remainder of the Division had arrived and we were ready to move up north from Salonika, they had already invaded southern Serbia and had effectually blocked the way between the retreating Serbian Army and any possible assistance from us.

The French Division, nevertheless, moved up the Vardar and endeavoured to effect a junction with the Serbs. They got through the Demir Kapu (Iron Gates of the Vardar) as far as Krivolak, and the 10th Division held the Bulgars on their right flank along the frontier from Strumitza to Doiran till we withdrew on December 6th, 1915.

From the beginning it was evident that the Signal Service in Salonika was not going to obtain any assistance from the local authorities. For over a month they would not permit the laying of any cable lines whatsoever in the town of Salonika, or along any of their telegraph routes, so immediately on arrival, October 5th, 1915, visual signalling was established from the "Splendid Palace Hotel," Base Headquarters, to the 29th Infantry Brigade at Lembet Camp, and to H.M.S. *Albion*, whence messages were transmitted by wireless to Mudros and London.

When the 10th Division moved up to Doiran, early in November, the sole means of communication was by despatch riders, who travelled on the daily train to Doiran Station, which, incidentally, still continued to run right through Bulgaria to Constantinople.

On the arrival of the 12th Corps Signal Company (Captain G. G. Rawson, M.C., R.E.), a D5 cable line was laid along the Greek Railway route from Salonika to Doiran station. It is interesting to note that this line, 45 miles long, was laid from both ends, and buzzer communication was established through a gap of 20 miles by induction on to the Greek telegraph wires. The line, however, was soon completed, and Morse communication established on November 20th, 1915. By this time the 10th Signal Company (Captain L. S. M. Smithers, Indian Army), had Morse communication from Doiran Station to Divisional Headquarters at Dedeli, and vibrators working to their three brigades at Hasanli, Calkali and Ormanli. It was found that a D Mark III telephone was capable of working through 11 miles of D1 cable, if care was taken in the laying of the line to keep it off the ground wherever possible, by means of bushes, existing poles, etc.,

The country in which the Salonika Army was operating was somewhat similar to the N.W. Frontier of India, that is to say, suitable for pack transport only, except along the main roads, which

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were few and far between. It consisted mainly of steep hills covered with rocks, and rising to 5,000 feet, interspersed by deep ravines often devoid of even a foot track.

In addition to the natural difficulties of terrain, the climatic conditions were most trying to British troops. Extremely cold and wet in winter, frost and snow prevailing for several months in the wind-swept uplands, varying to tropical heat (113° F. in the shade) for the greater part of the summer. From April to September military operations or other work were impracticable for three or four hours in the middle of the day. The so called "Vardar" winds blew for four or five days with unrelenting fury, causing a fine Balkan dust to penetrate and settle everywhere, even on the food. Added to this, the low lying valleys were alive with the *anopheles* mosquito, and both mild and malignant malaria were prevalent throughout the country.

At the end of November, 1915, snow began to fall and during the first week in December it was three feet deep everywhere north of Doiran. This was the same blizzard that visited the Gallipoli peninsula shortly before the evacuation. During the night the temperature dropped to seven degrees below zero, and consequently the infantry of the Division, who were on top of the hills, suffered very severely from frostbite, and in some instances the men were actually frozen to the rocks and their machine-guns.

On December 6th, the 10th Division was heavily attacked on a two Brigade front by the Bulgars in mass formation. Visual signalling was used on several occasions during these operations, and proved extremely useful as a stand-by when the cables were cut. This division fought a stubborn rear-guard action, they eventually withdrew from their position in Serbia on December 12th, and were within the Salonika defences by the 18th. The Bulgars only pursued as far as the Greco-Serbian frontier.

Meanwhile the 22nd, 26th, 27th, and 28th Divisions had now arrived from France, and established a defensive line round Salonika known as the 'Bird-Cage.'

Salonika Defences.

By the end of the year an elaborate system of poled cable lines had sprung up. The longest of these was from Hortiach, via Ajvasil and Langavuk, to Stavros. This line was nearly fifty miles long; it was laid through unknown country in three days, as communication was urgently required with the 29th Brigade, who had gone round to Stavros by sea. About 15 miles along the southern side of Lake Besik the cable followed the old Via Ignatia, through a marsh. It was *just* possible to work a vibrator through this 50 odd miles of D5 cable on the ground, from Hortiach to Stavros. It was decided to pole the line throughout, but only 200 airline poles were available

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for this job, and so 2,000 2½" x 2½" 15ft. scantlings were obtained from R.E. Base Park and mainly used—the airline poles being used wherever the cable ran near our own trenches.

When the poling was completed, this line gave loud telephone speech throughout its entire length. No insulators were available; the cable was attached to each pole by a clove hitch. Notwithstanding this it proved quite satisfactory, and was in use for nearly 18 months, before it was finally replaced by a permanent air line.

On January 9th, 1916, the Fourth Army Signal Company, (Major A. H. W. Grubb, D.S.O., R.E.), together with Nos. 1 and 3 Airline and A.H. and A.J. Cable Sections, arrived and immediately took over all signal work in the town of Salonika from XII Corps Signals, and established a Signal Office (SAR.) at Army Headquarters in the Rue Reine Olga, near the British Consulate. An extensive programme of 'comic line' construction was undertaken forthwith. Telephone pairs were first built, of 40lb. bronze wire and bobbins, on such poles as could be obtained locally, from A.H.Q. at Salonika to XVI Corps Headquarters at Kirechkoj and 10th Division at Hortiach. After this a semi-permanent route was constructed to replace the two-wire airline routes erected by XII Corps to Ordnance and Main Supply Depots, some few miles outside the town on the Monastir Road. Similarly, all other signal lines were gradually strengthened or replaced by semi-permanent lines. Later, these lines were again replaced as opportunity offered, by absolute permanent lines, in accordance with strict G.P.O. practice, until finally it was possible to hold a telephone conversation from G.H.Q. to any of the British Headquarters.

In March, 1916, a consignment of 12-pair V.I.R. multicore cable arrived and was used to replace the vast number of D5 cables that had been erected on the Electric Power standards in the town of Salonika. A wooden arm was wedged into the lattice work of the posts, and projected about 6 inches toward the road; a steel suspension wire was run along these arms, and the multi-core cable was hung from this wire by means of raw hide suspenders. That there was practically no inductive hum, or interference due to leakage from either the power or tramway wires, speaks well for the quality of this cable.

SPECIAL PACK EQUIPMENT.

During this time the Divisional and Corps Signal Companies had been experimenting with devices for carrying and laying cable from pack mules. The most satisfactory type of equipment was a special saddle, with a vertical spindle mounted centrally, designed to take a *one mile drum* of D5 cable. Needless to say that as the load was entirely on the centre of the animal's back, care had to be taken, firstly, to select a strong mule, and secondly, not to overload him

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with too heavy a centre load—hence the *one mile drum*. The chief advantage of this system was that cable could be paid off at any angle irrespective of the direction of travel of the mule, which was a great asset in negotiating tortuous mountain paths and re-entrant nullahs. Incidentally, having the cable on *one mile drums*, enabled two of them to be slung on either side of a mule for transport purposes.

A revised War Establishment was prepared and issued for Divisional Signal Companies on a pack transport basis.

Advance to Struma-Doiran Line.

Early in April, 1916, British cavalry moved forward and took up positions north of Kukus, and along the Struma River in front of Orljak; they were supported by the 22nd and 10th Divisions respectively. A twenty-three mile route of four wires was built along the railway from Salonika to Kukus, by 3 Airline and 1 Cable Sections, in 14 days.

XII Corps Signals maintained communication with the cavalry on the Struma, by establishing their Report Centre at Orljak; this involved a great deal of maintenance work on the old Turkish telegraph route which existed between Salonika and Seres. This route was built of two 800 lb. iron wires (used for Constantinople-Monastir-Valona-Italy telegraph lines), and two 400 lb. iron wires (used for Constantinople-Salonika-Uskub-Serbia line). Some of the spans across ravines were nearly half a mile in length, most of the poles were nearly rotted through, 6 inches below the ground, and "bell-hanger" joints in the wires were quite common. At this time the Greeks were using 2 wires to Seres; we appropriated the other two, and the French ran two 100 lb. bronze wires for their own use.

At 2.30 a.m., on May 6th, 1916, a German Zeppelin was reported over Karasouli, 45 miles N.W. of Salonika. Signals had reported the information to G.H.Q. and distributed it to the Royal Navy and all A.A. defence units, ten minutes before the Zeppelin arrived over Salonika. As the airship approached the town it was caught by our searchlights, and after a good deal of shooting it was hit by a 6-inch shell from a monitor, and came down in flames over the Vardar marshes at 3.30 a.m. This was the first Zeppelin brought down in the war.

Lieutenant-General G. F. Milne, C.B., D.S.O., took over command of the British Salonika Army on May 9th, 1916 from Lieutenant General Sir Bryan Mahon, K.C.V.O., C.B., D.S.O., who proceeded to Egypt.

By the end of May, 1916, the general position in Greece had been consolidated, and General Sarrail had been able to push French troops up to the Greco-Serbian frontier, west of the River Vardar.

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The right-hand sector from the Vardar to the Gulf of Orfano, a 90-mile front, was gradually handed over to the British.

XII Corps Advanced Report Centre moved via Mirova and Kirec to Janesh, where it remained for over two years. The XII Corps, composed of the 22nd and 26th Divisions, (Captain G. E. Sampson, D.S.O., R.I.F., and Major A. C. J. Stevens, R.E., commanding the Signal Companies respectively), took the left half sector, from the Vardar to Lake Doiran, a 10 mile front, where they found the Bulgars well dug in across the "Pip" ridge, and in front of the "Petit Couronne," in what was possibly the strongest natural defensive position ever occupied in history. The whole of our line was dominated by a hill called the "Grand Couronne," some two miles behind the enemy's line. Here the Bulgars built an O.P. (16 feet of concrete), from which they could observe practically every movement on the XII Corps front, and on a clear day could see the ships entering and leaving Salonika Harbour, forty miles away.

The inevitable result was that position warfare, exactly similar to that in France, was immediately established, and lasted until September, 1918.

During this long period, work for Signals never ceased. The XII Corps area was extensive, and it was soon well intersected by permanent routes.

Heavy artillery required signal communication, O.P. exchanges and flash spotting instruments were made and installed, and lines were built for sound ranging. Listening sets and screening sets were installed along the front line, and a pigeon loft was established at Janesh, Corps Headquarters.

A Corps Signal School was formed, and trained a large number of regimental officers and men.

Cables laid along the ground did not last long as a rule, being frequently destroyed by grass fires. Cables were laid across Lake Ardzan and lasted well, and were often the only means of telegraphic communication to troops in the Vardar area, as main routes running parallel to the front line were often damaged by shell fire and by bombing from the air.

Wireless communication was established between Corps and Army Headquarters, and also for anti-aircraft purposes. Power buzzer amplifiers were also used with success in the forward areas in the later stages of the campaign.

DIVISIONAL SIGNALS.

With regard to Divisional Signals, the rocky nature of the ground in the Doiran sector made all trench digging very difficult, so that special cable trenches for buried cable were rarely constructed.

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It was found that cable was best protected by laying it in shallow trenches about 9 inches deep and as narrow as possible. This protected it from everything except as a direct hit, and also from what was more often the cause of faults, the impedimenta of digging parties. " Laddered " cables were largely used by Brigade Sections.

When cable was laid on the ground it was liable to destruction by an invention of the R.A.M.C. consisting of a mule dragging a kind of stretcher, the end of which trailed on the ground, with a spike attached. The result may be imagined.

During actual operations backward Visual Signalling by lamp was used as an additional means of communication from the front line to Brigade Headquarters. This was found particularly useful because Brigade Command Posts were usually situated on hill tops. Within the Battalions visual was little used, owing to the dust caused by the enemy's H.E. shells. In some cases forward visual signalling was made possible by using lamps with a long tube to prevent the rays spreading, and on some occasions the heliograph proved most useful.

As soon as position warfare was reached, Divisional Signals were chiefly concerned in replacing the original cables laid to Brigades by semi-permanent routes. This was a long process, owing to the shortage of stores, shortage of men, owing to malaria, and the long distances to be traversed.

The presence of a German listening set on the Doiran front was a cause of much annoyance. There is no doubt that it obtained much valuable information before it was possible to instal a complete metallic system of circuits Even then the leakages caused by cable rubbing on rock edges did not make them by any means immune from over-hearing. It took many months to impress on Staff and Regimental officers the importance of this, and it was really only brought home to them when our own listening sets were installed. Our listening sets obtained little of value from the intelligence point of view, but their " Police " work was most valuable. Screening buzzers were used with some effect, it is believed, at any rate, by their means, Divisional Signals soon got to know whose lines were faulty, as complaints were received from irate Brigade, Battery and Battalion Commanders, that they could hear nothing on these telephones except a .....buzz !

First a French, then an Italian Division, and eventually our 28th Division (Major H. C. Saunders, D.S.O., R.E., O.C. Signals), held the portion of the line from Lake Doiran to Lake Butkova known as the Krusha Balkans, or the Snevce position.

In May, 1916, the XVI Corps Signals (Major C. H. Prickett, D.S.O., R.E.), took over the lines up the Seres Road to Orljak—Advance Corps Headquarters being at Kilo 70—and, later on, the whole Corps established itself along the line of the Struma, from Lake Butkova to the sea. On this front conditions were entirely different.

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The total frontage was nearly 50 miles long, but this included Lake Tahinos, which was 20 miles long.

The line was held sometimes with three divisions, and sometimes with two. The first summer that we were up there, all the units in the plain were decimated by malaria, so the next year both the Bulgars and ourselves retired to the foothills, and left a 'no-man's-land' ten miles wide to be patrolled every night.

The 28th Division were on the left with their divisional headquarters at Turica. One of their brigades was at Bashanli, some 20 miles away, in the Krusha Balkans.

The chief problem for the Signal Companies was distance. "Comic" lines were used extensively. The 10th Divisional Signal Company R.E. (now Captain H.C.B. Wemyss, D.S.O., R.E.). improvised insulators by using the necks of bottles. They ultimately established a system of perfect telephonic speech on metallic circuits throughout their division, thereby enabling all units to telephone messages direct from one to another. This saved their signal offices a very considerable amount of traffic.

The 27th Divisional Signal Company, R.E. (Major E. H. Varwell, D.S.O., R.E.), had their divisional headquarters on the Seres Road, and one of their brigades at Ano Krusoves, between Lake Tahinos and the Gulf of Orfano, 25 miles away. This brigade had to maintain communication with the Navy and the R.F.C. at Stavros. The Signal Company made good use of the locally designed apparatus for laying D5 cable from pack mules (already described) on more than one night attack. The great fear of the infantry that the mules would give them away by braying was guarded against by a specially designed muzzle, which proved most effective.

ARMY AND L. OF C. SIGNALS.

During this time the Army Signal Company had been steadily building up a permanent system of both telegraphic and telephonic communication, supplemented by regular D.R.L.S., and reinforced by Wireless and Pigeons. By the end of 1916, eight signal offices and telephone exchanges were in operation in and near Salonika. The Army also maintained signal offices at Stavros, Langavuk. Guvesne, Likovan, Salamli and Sariguel. All divisional and, corps headquarters and all the above army signal offices, were in telephonic as well as telegraphic communication. The practice of building well-balanced pairs of wires for telephone use, and superimposing the telegraph circuit, was found to be most satisfactory, and resulted in a great saving of wire, as several of these lines were 20 to 30 miles long.

The average number of messages handled daily at G.H.Q. Signal Office was 3,000 telegrams and 1,800 telephone calls.

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Plate II is a diagram showing the main telegraph and telephone circuits in use at this period.

Early in December, 1916, a L. of C. Signal Company was formed under Major A. C. J. Stevens, D.S.O., R.E., *to take over the great development of services at the Base and in the L. of C. Area.

At the same time a Signal Depot was established under command of Lieut. W. A. Young, R.E. Instructional classes for visual signalling and forward cable work were started there, while classes were held at the Army Telegraph School at G.H.Q., for Office Telegraphists and Permanent Linemen.

The 60th Division, with its Signal Company (Major A. G. L. Sladen, R.E.), had now arrived from France. Two Brigades were sent north of the Snevce area, and one Brigade south to Katerini. A telegraph line to the latter place was taken over for certain hours of the day from the Greeks. A pigeon service from there to Salonika was also established, and worked well to begin with, but after a few months the birds became involved with local birds, and several failed to home.

The greater part of 1917 was spent by all Signal units in consolidating and improving their lines. The 7th and 8th Mounted Brigades, and the 10th and 60th Divisions were sent to Egypt.

From 18th to 21st August, the whole of the centre portion of the town of Salonika was burnt to the ground; this included the Base Signal Office, so a new telephone exchange was opened at the Docks, for the many subscribers in that area. It is interesting to note that during the whole of these four days important communications from the G.H.Q. Signal Office were never seriously interrupted, thanks to the alternative lines in existence, and to the excellent work of the Signal Service personnel.

By the end of the year, a new line of L. of C. had been put into operation via Bralo and Itea, on the Gulf of Corinth, to Taranto in Italy. A telegraph line was constructed from Salonika along the railway to the Rest Camp at Bralo, and a telephone line from there to Itea. Telegraphic communication was also established from Bralo to Athens. The lines maintained in this area amounted to 180 miles of permanent line, carrying 294 miles of wire.

The number of signal offices in G.H.Q. and L. of C. area had increased to 33. The average daily traffic through the G.H.Q. Signal Office was 3,600 messages, and 3,660 telephone calls. There were 25 telegraph instruments working in that office, and 139 subscribers connected to the Telephone Exchange.

During the period January, 1916, to December, 1917, the Signal Park issued 12,300 miles of cable, 6,000 miles of bare wire, 27,300 poles of various sizes, 2,540 telephones, and 53,000 cells of all types.

* Captain R. A. C. Henderson, Cameron Highlanders, succeeded to the command of the 26th Division Signal Company, R.E.

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The above issues do not include stores brought out to the country by units, nor stores or wire obtained locally. Owing to the difficulty in obtaining a regular supply of stores from home, due to submarines and other causes, the manufacture of cells and buzzer telephone exchanges was inaugurated at Signal Park.

Wireless.

Very little has been said concerning the use of Wireless as a means of communication. It would naturally be assumed that in warfare in a country such as Macedonia, possessing practically no means of communication, such as roads and railways, and where the difficulties of erecting and maintaining ordinary line communication were very formidable, that wireless would afford an admirable method of communication.

The chief difficulties lay in the comparatively large distances to be covered and the types of apparatus available.

Great progress had been made in France in the development of W/T communication, but these developments were almost entirely along the lines of forward communications (*i.e.*, small Trench sets for communication between battalions and brigades or front line to support trenches), and practically nothing was done with modern type transmitters for longer distances.

The apparatus available was limited to the half kilowatt pack wireless sets, designed primarily for mule transport, and with a range of only 20-30 miles.

A complete system of alternative wireless communication was, however, established and maintained between each of the Corps Headquarters and G.H.Q. at Salonika.

A Wireless Company was formed under Captain K. J. Hayward at G.H.Q., and a permanent wireless station erected at Kalamaria, just outside the town of Salonika. This station was a "built-up" set with a range of about 50 miles, and standard sets were installed at each Corps Headquarters.

In addition to this, each Corps had its own Wireless organisation, and mobile Pack sets were sent to important strategic positions as alternative means of communication when the situation required.

In 1917, a system of W/T communication was inaugurated in co-operation with the R.A.F. and A.A. units to deal with enemy aircraft. Wireless stations were placed along the high ridges behind the front line commanding a wide view of No Man's Land. Trained R.A.F. observers were attached to each station, By means of code messages the approach of hostile aircraft was rapidly reported to aerodromes and A.A. gun positions, and so our fighting machines were able to get away from their aerodromes and meet the enemy machines before they reached our lines. This system proved very effective, as it not only enabled warnings to be given without loss

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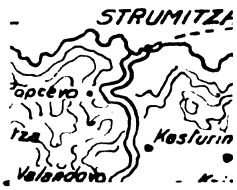
PLATE I

SKETC

MILES 5



SALONIKA ARMY H.Q.

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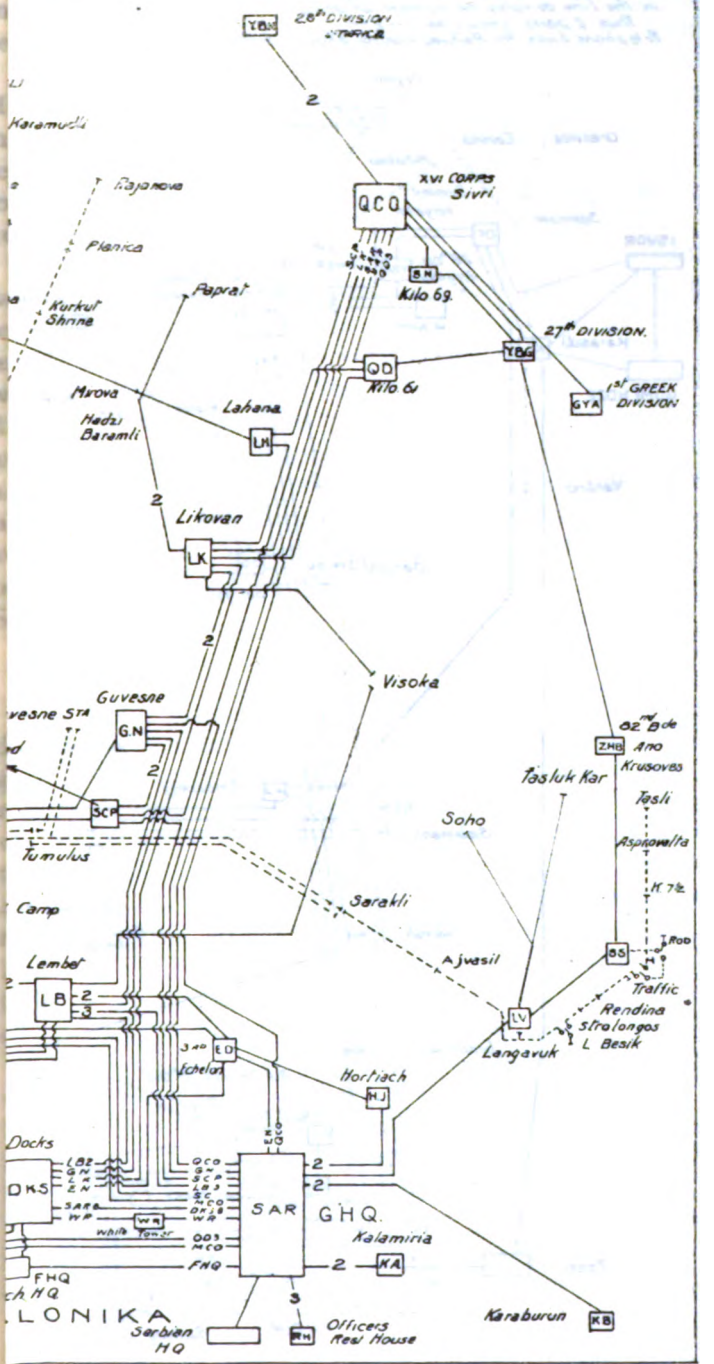
TELEPHONE TRUNK LINES.

28TH 1918.



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of time, but obviated the necessity for clearing main line routes for the transmission of aircraft warnings. Previous to this, considerable difficulty had been experienced in dealing effectively with the enemy aircraft, as the number of sites available for aerodromes was extremely limited, owing to the wild and mountainous country, and consequently they had often to be placed at a great distance behind our line, whence machines were unable to get away in time.

A special long range receiving set was installed at XVI Corps Headquarters (Kilo 61), by means of which the official news transmitted from Carnarvon was received each night. This news was sent to Salonika by despatch rider each morning, and served to form a basis of news from which the "Balkan News," the daily newspaper, was printed.

During the final stages of the campaign wireless communication was extensively used for inter-Corps and Corps to Division communication, and also proved useful in linking up the advanced units to advancing line connection back to G.H.Q. Relay working was adopted. The advanced station moved forward during the day with the "G" and "A" branches of the Corps, and sent back traffic during the night to a second station situated at the Corps signal office. At daybreak the first station moved forward with advanced Corps Headquarters, while the rear station moved at the same time along the newly completed section of line, and opened up again in the evening at the new Corps Signal Office.

Despatch Riding.

The motor cyclist despatch rider was also handicapped by the difficult terrain and the extreme climatic variations. The position gradually improved as existing roads were taken in hand and fresh roads and railways were constructed; but so far as concerned the working of a D.R.L.S. by motor cycle or car, it has to be appreciated that the Macedonian highways, as they existed on the arrival of the Allied Armies, were designed for the passage of no vehicle swifter than a bullock wagon, and that the mountain tracks, which the D.R's came to negotiate with such commendable reliability, had hitherto been innocent of traffic, save that of the mountain goat or the nimble-footed and long-suffering native pack-donkey.

The conditions, especially over the longer distances, imposed no small physical strain upon the riders, weakened as they often were by successive bouts of malaria. One of the most trying routes of all—though it had the redeeming feature of variety of scenery—was perhaps that from G.H.Q. to Stavros, on the Gulf of Orfano. This service was commenced twice weekly in October, 1916, and the double journey was roughly 150 kilometres. The route lay over the Hortiach Plateau, down either the Ajvasil or the Azrameri

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Pass to Langavuk, along the southern shore of Beshik Lake, and through the narrow and picturesque gorge followed by the little river Rendina on its short course from Beshik to the sea at Stavros. In the early days, particularly on this route, motor cyclists found it necessary—sometimes at the revolver's point—to protect themselves against savage attack by semi-wild dogs.

When heavy rain or snow made the roads impassable for motor-cycles, the despatch riders, mounted on horses or mules, and riding in relays, had to make the best possible time in very adverse circumstances. On occasions a light car—usually a Ford van—equipped with non-skid chains, succeeded in making the journey where a motor-cycle would fail; and it may here be said that in normal times, too, the actual bulk of correspondence to be carried sometimes necessitated the despatch of a car, or two motor cyclists riding in company. So far as concerned the services between G.H.Q. and the XII and XVI Corps Headquarters, once the Naresh and Seres roads respectively were thoroughly established, nothing short of heavy snow prevented the motor cyclists or cars from getting through.

BLIZZARD, 1918.

The telegraphic communications of the British Army were seriously interrupted on the 16th and 17th February, 1918, owing to a violent blizzard on the 16th, followed by a heavy fall of snow on the night of 16/17th. On the morning of the 17th all the trunk lines to the XII and XVI Corps were down, and nearly all the permanent and "comic" lines in the XII Corps area were completely broken. The lines in the XVI Corps area did not suffer to anything like the same degree. It is interesting to note that, whereas the lines in many cases successfully weathered the blizzard, they capsized during the steady fall of snow, as the poles and stays became overloaded by the snow and ice loading on the wires. All communications were speedily restored with D5 cable.

The original lines were replaced by stronger routes of heavier poles and shortened spans, not exceeding 60 yards.

SECOND LINE DEFENCES.

No sooner had the work of reconstruction been completed than the Germans started their March attacks in France; so the question of second and third lines of defence for Salonika became a serious problem. Signals built permanent lines along all roads and tracks by which withdrawals would be effected. A diagram showing the main trunk lines as they existed at the end of April, 1918, is appended. (Plate III).

(*To be continued*).

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TANK ASSAULT BRIDGE.

By MAJOR G. LE Q. MARTEL, D.S.O., M.C., R.E.

The object of this trial was to produce a design for a very light bridging expedient that would enable tanks to cross rivers in the face of enemy opposition. The proposal was to use light skeleton timber boxes which would be carried forward rapidly and laid in the river to act as "stepping stones" for the tanks. These boxes were to be capable of being placed in position in a few minutes, so that the enemy would be taken by surprise and the tanks would be enabled to cross before he could concentrate against them. It was only intended that the boxes should be strong enough to take a few tanks across at each place; these tanks would assist in forming a bridgehead, and a proper tank bridge could then be constructed. In fact, the device was intended to provide for tanks what the Kapok bridge provides for infantry.

In a device of this nature exact calculations for strength are not possible, but an attempt was made to construct boxes which would just take the stress, with practically no factor of safety. It was then hoped that the trial would show where the weakness lay, whereas boxes which were known to be strong enough would probably be unnnecessarily heavy, and would provide no real information. The bracing is in compression (except for the longitudinal bracing), and no reliance has, therefore, to be placed on the holding power of the nails.

Two trials were carried out, the first being with a Birch gun, and the second with a fully-loaded tank weighing just over 12 tons. In the first trial the river was 3ft. 6ins. deep and 50 ft. wide. Five boxes were used, three being rectangular, and the remaining two were "shore piers." The boxes were spaced 4ft. 3ins. apart and connected by ropes along each side, at the bottom of the boxes. The boxes were lined up on the edge of the river and four sappers carried each box, the ropes being taken across to the far side of the river. On the word to advance the whole moved forward, and the boxes were in position in 1½ minutes. The middle three boxes were floating and the outer boxes were aground; light lines were fastened up stream to each box to dress the bridge. The Birch gun then crossed on the boxes without any difficulty or damage. On the second trial, which took place ten days later, the same boxes were used for the test with the tanks. The water

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level had fallen, which made it more difficult to launch the boxes. On this occasion the operation was carried out as in war. A Kapok assault bridge was launched to enable six sappers to cross the river with the ropes, and the boxes were then hauled across, the whole operation taking three minutes (this time would be much improved on with practice). The first tank then crossed and slightly damaged the first box, and forced the last box deep into the muddy bank, but nevertheless the tank crossed the river without difficulty or delay.

A second tank was then sent across, but it did not steer very accurately, and the left-hand track was half over the edge of the first box; this caused the box to collapse and ended the test. If the tank had steered accurately it might just have crossed, but the margin of safety was very small. A tank was then taken over a single box on dry land to ascertain what part would fail first. In a river the weight is distributed over three boxes, but the whole weight might come momentarily on one box. The tank advanced over the edge of a bank and stood momentarily with the full weight on the box; then the box suddenly collapsed endways, showing that the longitudinal bracing was insufficient.

The conclusion is that this bridging device can be made satisfactory for wide and shallow rivers. A depth of six or seven feet is probably the maximum which could be negotiated; there are many rivers which have only this depth and yet form serious tank obstacles. As regards the detail design the lessons learnt were:—

(*a*) More longitudinal bracing is required.

(*b*) The boxes should be longer, to allow for inaccurate steering on the part of the tank (the present design demands very precise steering which could not be expected under war conditions).

(*c*) The capsills should be bound with hoop-iron, to reduce splintering.

(*d*) Further trials are necessary to determine whether a tank can change direction to a small extent while crossing these boxes; if not, then a very wide shallow river cannot be crossed without using unduly long boxes, because the tank is bound to lose direction to the extent of a few degrees as it crosses over the boxes.

It is estimated that two carpenters could construct one of these boxes in one hour. For transport purposes the two trestles which form the sides of the box can be carried separately, and the bracing is carried loose and nailed on *in situ*. In this way five boxes can be packed in one G.S. wagon, and the boxes can be assembled in about five minutes.

The boxes were designed and the trials carried out by the 17th Field Company R.E., and further tests are to be made.

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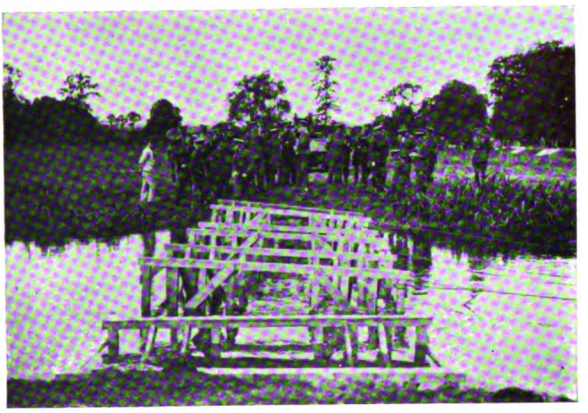
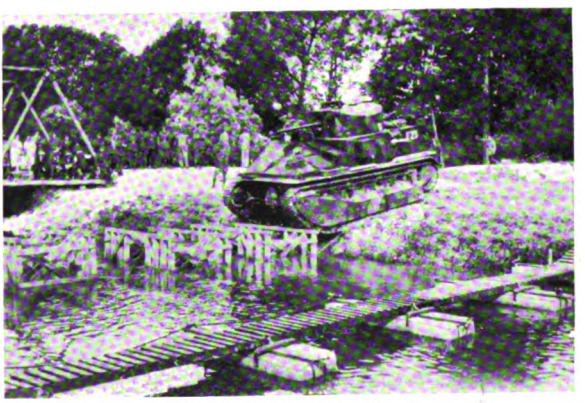
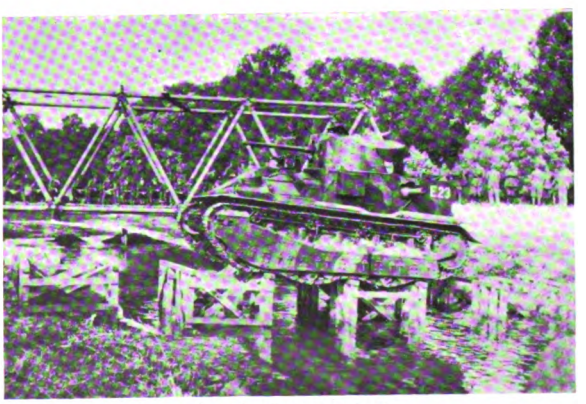
TANK ASSAULT BRIDGE.



The Bridge in position.



A Tank about to cross.



A Tank crossing.

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LIEUTENANT-GENERAL WILLIAM SPRY.

The Institution has recently obtained possession of the ten commissions of William Spry, an engineer officer who died as a Lieutenant-General in 1802 He saw little active service, except that he took part in the very interesting and successful expedition against Cape Breton and Louisburg in 1758, and apparently remained in the island carrying out demolitions and new works for some years, and was also employed at Quebec after its surrender. In his later years he became one of the chief authorities on fortification, and remodelled the Thames defences. He is credited with the project of the Chatham Lines. His death occurred as the result of a chill caught when witnessing a balloon ascent during the Peace of Amiens. His commissions give an interesting record of the proceedings of the War Office and Board of Ordnance at that time.

The *first*, as *Practitioner Engineer*, was issued by the Board of Ordnance on the 17th December, 1755, and reads as follows :—

"By the Right Honourable Sir John Ligonier, Knight of the Bath, Lieutenant General, and the rest of the Principal Officers of his Majesty's Ordnance. To William Spry, Gent., Practitioner Engineer.

By Virtue of the Authority to Us by the King's most Excellent Majesty in this behalf given (in the Absence or Vacancy of a Master General of the Ordnance) upon the good Testimony and Assurance which We have received of your Loyalty, Integrity and Ability, We do hereby nominate, constitute and appoint you the said *William Spry* to be one of the Practitioner Engineers belonging to this Office upon the Establishment approved of by Order in Council 22 August, 1717, and his Majesty's Warrant 16 December, 1755. You are therefore to improve yourself in the Study of the Mathematicks, Fortifications and other Sciences which may render you capable to serve as an Engineer upon any Occasion, and likewise to observe and follow such Orders and Directions as you shall from time to time receive from the Master General of the Ordnance, the Lieutenant General and Principal Officers of the same for the time being, the Chief Engineer, Directors, or any other your Superior Officer, according to the Rules and Discipline of War, in pursuance of the Trust hereby reposed in you. Given at the Office of Ordnance under Our Hands and Seal of the said Office this seventeenth day of December, 1755, in the Twentyninth Year of his Majesty's Reign."

Signed by J. L. Ligonier; Charles Frederick; A. Wilkinson; W. R. Earle; F. J. Charlton. "Enter'd in the Office of Ordnance 26th day of December, 1755." Signed, W. R. Earle, "Cl. Ordn'ce." The document has Ordnance Seal and stamps to value of 7/6.

Two months later, on 26th February, 1756, Spry received from King George II his *second* commission as "Ensign to that Company, whereof Esqre. is Captain in Our Third Regiment of Foot,

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or the Buffs, Commanded by Our Trusty and Welbeloved Colonel George Howard."

This Commission is signed "George R." and, underneath, "Entered with the Secretary at War, Thos. Sherwin," "Entered in the Office of Thomas Gore, Esqre., Comry. Genl. of Musters, John A. F. Hesse;" "By His Majesty's Command, H. Fox." This document has the remains of the Royal Seal and 7/6 stamp.

On 14th May, 1857, he received from the King the *third* commission :—

"George R.

George the second by the Grace of God King of Great Britain, France and Ireland, Defender of the Faith, &c. To Our Trusty and Wel-beloved *William Spry* Gentleman Greeting. We reposing especial Trust and Confidence in your Loyalty, Courage, good Conduct and Ability, do by these Presents constitute and appoint you to be one of the Practitioner Engineers upon the Establishment of Our Office of Ordnance and to take your Rank as Ensign in Our Army. You are therefore to improve yourself. . ." etc., as before.

"Entered with the Secretary at War, Thos. Tyrwhitt"; "By His Majesty's Command, Marlborough"; and entered as before by W. R. Earle. There is no seal on this document, but stamps as before.

The *fourth* Commission is from the King, dated 27th September, 1757, appointing him "Lieutenant to that Company whereof Esqre. is Captain, in Our Third Regiment of Foot, or the Buffs, commanded by Our Trusty and Welbeloved Colonel George Howard," and is entered as before by Thos. Tyrwhitt and John A. F. Hesse, and issued "By His Majesty's Command, W. Pitt." It is signed by the King and sealed and stamped like the second.

The *fifth* Commission, dated 4th January, 1758, is like the third, and appoints Spry "to be one of the Sub-Engineers upon the Establishment of Our Office of Ordnance and to take your Rank as Lieutenant of Foot in Our Army (in the room of Charles Hubert Herriott promoted)" It is signed by the King, entered by Tyrwhitt and Earle and issued by Marlborough. It is not sealed, but bears 7/6 stamps as the others.

The *sixth* commission was issued by the Board of Ordnance three days after the fifth. It reads as follows :—

"Charles Duke of Marlborough, etc., One of His Majesty's Most Honourable Privy Council, Knight of the Most Noble Order of the Garter, Lieutenant General of His Majesty's Forces and Master General of the Ordnance, etc., to *William Spry*, Engineer. By Virtue of the Authority to Me, by the Kings most Excellent Majesty in this behalf given upon the good testimony and assurance which I have received of your Loyalty, Integrity and Ability, I do hereby nominate, constitute and appoint you, the said *William Spry*, to be one of the Engineers on the Expedition to North America. You are, therefore carefully and diligently to discharge the Duty of an Engineer in the said Service by doing and performing all

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manner of Things thereunto belonging, likewise to observe and follow such Orders and Directions as you shall from time to time receive from Me, or the Master General of the Ordnance for the time being, the Lieutenant General, Principal Officers of the same, the Commander in Chief on the said Expedition, or any other your superior Officer according to the Rules and Discipline of War in pursuance of the Trust hereby reposed in You: And for your Care and Diligence to be taken herein you are to have and receive the Allowance of Eight Shillings p diem to be paid to you out of the Treasury of this Office—the said allowance to commence the First Day of this Instant and to continue so long as shall be thought requisite and necessary for His Majesty's Service. Given at the Office of Ordnance under my hand and Seal this Eighth Day of January, 1758, in the Thirty-first Year of His Majesty's Reign."

It is signed "Marlborough," issued "By Command of His Grace the Master General of the Ordnance," by Jacob Bryant, and "Entered in the Office of Ordnance 10 day of January 1758 for the Honble. the Clerk of the Ordnance," by Dan. Kemp. The seal bears His Grace's private coat of arms and the stamps are the same as before.

The *seventh* Commission, dated 17th March, 1759, appoints Spry "To be one of the Engineers Extraordinary upon the Establishment of Our Office of Ordnance and to take your Rank as Captain Lieutenant of Foot in Our Army." It is signed by George II and by Geo. Sackville and entered by Thos. Tyrwhitt and W. R. Earle, "with the Secretary at War" and "in the Office of Ordnance" respectively. There is no seal, but the stamps are as usual.

The *eighth* is the first of the Commissions granted by George III and is dated 1st January, 1783. It appoints Spry "to be one of the Lieutenant Colonels of Engineers upon the Establishment of Our Office of Ordnance and to take your Rank as Lieutenant Colonel of Foot in Our Army." It is signed by the King and by "Richmond, etc., Master General," "Entered with the Secretary at War" by M. Lewis, "Entered in the Office of Ordnance, 25 Janry, 1783," by "G. Crawford, Clerk of the Ordnance," "Entered with the Comry. General of Musters" by John A. F. Hesse," not sealed, but stamped like the others.

The *ninth* Commission appoints Spry a "Major General in Our Army." It is dated 20th December, 1793, signed by the King and Henry Dundas, "entered with the Secretary at War" by M. Lewis, and "with the Commry. General of Musters" by Wm. Woodman. It bears the royal seal, a stamp of 5 shillings, and is endorsed on the back "Fees £12."

The last commission, appointing Major General William Spry to be a Lieutenant General, is dated 26th June, 1799, and is signed by the King and "Portland." It is entered by Lewis and Woodman and bears the royal seal and a stamp of 12 shillings and sixpence. The endorsement on the back is "Paid Fees £17 2 0."

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ROLL OF THE CORPS OF ROYAL ENGINEERS OF IRELAND, 1251-1801.*

Compiled by MAJOR W. P. PAKENHAM-WALSH, R.E., F.R.S.A.I.

PREVIOUS to the Parliamentary Union of Great Britain and Ireland in 1801, the latter country possessed its own corps of Royal Engineers, which, with the Royal Regiment of Artillery of Ireland, was under the orders of an Irish Master-General of the Ordnance.

The history of this Corps has been greatly neglected, only a few passing references being made in General Whitworth Porter's "History of the Corps of Royal Engineers," while the roll, as given in Edwards' "List of Officers of the Corps of Royal Engineers, 1660-1898," is not complete.

The present writer, in the course of family genealogical researches some years ago, came across some interesting facts in connexion with the Corps, which have sugggested to him the idea of collecting materials for a history; and he was surprised at the early date to which the Corps could trace its ancestry.

The present compilation does not profess to be by any means complete, but is put forward in the hope that it may be of interest to members of the Corps, and that some of them may be able to assist with further information as to the Corps in general, or individual members of it, for which the writer will be most grateful. To avoid unnecessary trouble, the following list of works already consulted is appended :—

Calendars of State Papers, Ireland.
"Dictionary of National Biography."
"Liber Munerum Publicorum Hiberniae."
Porter's "History of the Corps of R.E."
Edwards' "List of Officers of the Corps of R.E."
Stafford's "Pacata Hibernia."
Crawley's "Cæmentaria Hibernia."
Gilbert's "History of Dublin."
Gilbert's "Parliament House, Dublin."
Irish Army Lists and Dublin Directories, 1730-2801.

* This article which appeared in *The Journal of the Proceedings of the Royal Society of Antiquaries of Ireland*, is reprinted by permission of the Council of that Society.

The following articles by the same author have appeared in *The Royal Engineers Journal* :—

Lieut.-Col. Thomas Burgh, 1700-1730. (Aug. 1907). The Irish Houses of Parliament, Dublin, (Sept. 1907). Capt. Sir Josias Bodley, 1612-17, (Oct. 1906). Capts. Sir Thomas Rotheram and Nicholas Pinnar, 1617-44, (Aug. 1909).

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ROLL OF OFFICERS.

251. June 22nd. The King directs the justiciary of Ireland to "cause the King's tles, houses and fortresses to receive the repair they require by view of good and lawful n who shall answer therefor at the Exchequer."—*Clarendon, Patent 35 H. III m. 7.*

eeper of the King's Works of the Castle of Dublin."

9-85. Thomas Burel.

(*No titles mentioned.*)

3. John de Strattone.
John de Iddeshal, Clk.

6–7. John de Ideshale.
Richard de Pontevse.

7–9. John de Ideshale.
John Boet.

9. John Boet.
John de Colewells.

0. John Boet.

upervisor of the Works of the Houses of the Castle of Dublin and the Exchequer."

4. John Matheu.

uperintendent of the King's Works."

5-6. Robert Ingmainacon.

eeper of the King's Works of the Castle of Dublin."

5. Luke de Hvnkeley.
Thomas Dyere.

4. John de Mauncestre. . . . . *He was also Keeper of the Ordnance.*

eper (Garnefourc) of the Castle of Dublin and also of the King's Works of the said Castle and Houses of the Exchequer."

2. John de Wiltoun.
4. John de Carleton.
8. John Scrop.
1. William Spaldynge.

2-81. John More . . . . . *He had jurisdiction throughout Leinster.*

lerk of the King's Works" (with jurisdiction all over Ireland).

8. Walter Eure.

eeper of the King's Palace within the Castle of Dublin and Clerk of the Works of the said castle."

5-1441. John Coryngham.

" Carpenter of the Castle of Athlone."

1270-72. Nicholas de Gloucester.

1280. In this year "250 Cæmentarii Carpentarii, Operarii, et Fossatores" were sent into Ireland for the King's Works.

" The King's Carpenter."

1293. Adam de Claverle.

" Chief Carpinter of the Castles, Manors, and other the King's Works."

1343-57. Adam de Carleton.

1441-1508. No records found so far.

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"Clerks General of the Works and Buildings, viz., of all the King's Honours, Castles, Manors, and all other his works." (By Patent.)	"Clerk, Comptroller, and Surveyor-General of the Ordnance." (By Patent.)	"Surveyor-General of the Lands, Plantations, and Mines." (By Patent.)	Other appointments.
t. Hen. VIII Nicholas Wilson, Gent.			—
(Appointments held conjointly.)		1548. Walter Cowley.	"Employed in furtherance of Fortifications."
t. Hen. VIII (regranted 1546)-1553. Edward Walleis, Gent.		1551. Robert Record.	1551-79. Mr. F. Rogers.
1553-64. Peter Ford, Gent.		The above two served in both England and Ireland.	
1564 (28th July). George Tresham, Gent.		1552-73. Michael Fitzwilliams.	
1564 (8th Sept.). Stephen Erbery, of London, Merchant Taylor.			"Clerk and Surveyor of the Works & building at Carnfergus.
1565-83. Nevill Sands, Gent.		1573-90. Lancelot Alford.	1576. Owen Lanc[illegible] Gent.
1583-93. Michael Kettlewell, Gent.			
1593- Francis Capstoke, Gent.	1593. Stephen Jennyngs, Gent.	1590. "Office passed to meet man" (?Sir G. Fenton).	—
1594-99. Stephen Jennyngs, Gent.			
1599. Sir Geoffrey Fenton, Knt.	—	(?)-1602. Sir Geoffrey Fenton, Knt.	1601-2. Seige of Kinsale.
1600-12. Samuel Molineux, Gent.	"Comptroller of the King's Works." (By Patent.)	1602-43. Sir William Parsons, Knt.	Trenchmaster Captain Josias Bodley.
1612 (Mch. 16)— Samuel Molineux, Gent. / Tristram Gawen, Gent.	1606. Fras. Annesley, Gent.		"Ingeneer" Paul Ive.
	—		—
Office combined with that of Superintendent of Castles in 1612 and renamed, "Directors General and Overseers of the Fortifications and buildings." (By Patent.)			1602. Seige of Dun Trenchmaster Capt. Francis Shane. "Superintendent Castles" (on the Establishment of the Army).
1612-1617. Capt. Sir Josias Bodley, Knt.			1607-12. Captain Josias Bodley. Office incorporated Director-General Fortifications, [illegible]
1617-34— Sir Thos. Rotheram, Knt. / Captain Nicholas Pynnar.		1643. Office combined with that of Director-General of Fortifications and held by Pynnar.	—
1634-44 Capt. Nicholas Pynnar.			"Master Carpenter (By Patent) 1618-(?). John Ba[illegible] ter.
1644-61. Colonel John Payne (appointed temporarily by the Marquis of Ormond, Lord Lieutenant of Ireland).			—
—	—		"Our Engineer 1625. Capt. Nor[illegible]
"Directors-General and Overseers of the Fortifications and Buildings and Surveyors-General." (By Patent.)	"Comptroller of the Ordnance" (under the Director-General of Fortifications).		—
1661-70— "Capt." John Paine. / Capt. John Hullam.	1662. Capt. Hugh Magill.		"Master Carpenter (By Patent) 1661. John Mi[illegible]
—	—		

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In 1669 the Engineer Establishment was definitely fixed at 3 officers.

f Engineer of Ire-nd; also styled, irector, Surveyor, id Overseer-General the Fortifications, uildings, Roads, ines, Plantations, c.	*Second Engineer of the Fortifications.*	*Third Engineer of the Fortifications (for service with the train.)*	
-84. Sir William obinson, Knt.	*1669-1698. No names traced so far.*		*Engineers on the Irish Establishment, 1689-91.*
-88— r Wm. Robinson, nt. iam Molineux.			Rudolph Corneille. Thomas Burgh. Wolfgang W. Romer. (*Transferred to English Establishment.*)
-1700. Sir Wm. obinson, Knt.	*1698-1705.* Rudolph Corneille.	*1698-1700.* Thomas Burgh.	—
-30. Thos. Burgh, .P. (*Lieut.-Col. 06.*)	*1705-1710.* John O'Bryan. (*Transferred to the English Establishment 1710.*)	*1703-19.* James Wybault (*Major 1719, transferred to Irish Artillery 1719*).	*Engineers of the English Establishment, who served in the Wars in Ireland 1689-91.*
	1714. John Corneille.	1719-33. John Corneille, Jr.	Col. Fras. Philipanneau de la Motte.
-33. Captain Sir lwd. Lovet Pearce, nt. (*From Nevill's ragoons.*)	*1733-62.* John Corneille, Jr.	*1733-63.* Lewis Marcell.	(*Acting Chief Engineer of the English Establishment in Ireland.*)
-44. Arthur obbs, M.P.			Col. du Cambon. Martin Beckman.
-52. Arthur Jones evill.			Jacob Richards. Holcroft Blood.
-66. Thos. Eyre. *ieut.-Col. 1763.*)			John Bodt. . . . Browne.
Office of Surveyor-neral was abolished 62.			— *Additional Engineer.* *1761.* Chas. Vallancey

SUBORDINATE OFFICES, 1739-63.

Engineer Office, Lower Castle Yard, Dublin.

buty to the Chief Engineer. . Joseph Jarratt.	*Clerk of the Works.* *1747-52.* Geo. Ensor.	*Clerk of the Accompts.* *1744-51.* John Wilkinson, Gent.	*Storekeepers.* *1739-48.* John Favier *1748-63.* Thos. Coote.

ie Establishment was reorganised on a military basis on the 30th June, 1760, as the "Corps ngineers of Ireland," and received the title of "Royal" in 1789-90. The Corps was shed in accordance with the Act of Union on 1st April, 1801, the officers being given the n of retiring on full pay or joining the English Establishment. Only one, Lieut. George it, accepted the latter alternative.

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ROLL OF OFFICERS OF THE CORPS OF ROYAL ENGINEERS OF IRELAND, 1760-1801.

Dates of Corps' rank given in ordinary type, and of Army rank in italics.

Name.	Previous Service.	Ensign.	Lieut.	Captain-Lieut.	Captain.	Major.	Lieut.-Colonel.	Colonel.	Major General.	Lieut.-General.	General.	Chief Engineer.	Remarks.
Henry M. Mason,	from 26th Foot,	..	..	..	..	*13.2.1762.*	13.3.1766	..	..	..	..	13.3.1766	Ret. 25.4.1776.
Thomas Piggott,	from 4th Horse.	..	..	..	..	*31.12.1771* 26.4.1776	7.5.1782	20.11.1782	*12.10.1793*	..	..	26.4.1776	Ret. 14.11.1793
Charles Vallancey,	from Capt. . . . Foot, ..	(addl. Engr.) 1761.	30.6.1760	..	26.1.1762	25.4.1776	*25.4.1776* 1.10.1789	*20.11.1782* 14.11.1793	*12.10.1793*	*1.1.1798*	*25.9 1803*	14.11.1793	Ret. 1.4.1801.
Charles Tarrant,	from English Establishment. Pract. Engr. 29.12.1755.	(English Estab.) 14.5.1757	(English Estabt.) 17.3.1759 *(24th Foot)* 5.9.1756	..	(Irish Estabt.) 27.1.1762	*29.8.1777* 1.10.1789	*19.3.1783* 14.11.1793	*1.3.1794* 1.4.1796	*3.5.1796*	*25.9.1803*	..	..	Ret. 1.4. 1801.
Thomas Jarratt,	from Irish Artillery ..	30.6.1760	27.1.1762	..	22.5.1766	*10.11.1780*	..	..	..	..	..	..	
Arthur Forth,	..	26.1.1762	3.5.1765	..	3.12.1785	..	..	..	..	..	..	..	
Joseph Shewbridge,	..	27.1.1762	22.5.1766	..	..	*1.3.1794*	..	..	..	..	..	..	Transferred to Irish Artillery 1.4.1778.
George Preston Vallancey,	..	3.5.1765	..	..	....*1778*	..	..	..	..	..	..	..	Transferred to 62nd Foot 1.9.1771.
Matthew Nash,	..	22.5.1766	..	..	..	..	..	..	..	..	..	..	Transferred to Irish Artillery 21.4.1778.
James Ferrier,	from English Establishment, Ensign, 23.6.1762	1.9.1771	..	..	1.10.1789	*14.8.1779* 14.11.1793	*18.11.1790* 1.4.1796	*21.8.1795*	*18.6.1798*	*30.10.1805*	..	..	Ret. 1.4.1801.
John Browne,	from 27th Foot,	..	..	1.10.1789	14.11.1793	*19.5.1795* 1.4.1796	*1.1.1800*	*25.7.1810*	*4.6.1813*	..	..	..	Ret. 1.4.1801.
Alexander Taylor,	..	..	1.10.1789	14.11.1793	1.4.1796	*29.4.1802*	..	..	..	..	..	..	Ret. 1.4.1801.
Henry Eustace,	..	..	8.5.1790	1.4.1796	..	*23.10.1798*	*25.9.1803*	*1.1.1812*	*4.6.1814*	*28.7.1830*	..	..	Ret. 1. 4. 1801.
George Armit,	..	..	14.11.1793	..	..	..	..	..	..	..	..	..	Transferred to English Estabt. 1.4.1801.

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MEMOIR.

CAPTAIN RICHARD DURRELL PANK, M.C., R.E.

RICHARD DURRELL PANK was born on September 26th, 1893, the second of the three sons of Lieut. Col. P. D. Pank, I.M.S., and Mrs. Pank. The eldest, Captain P. E. D. Pank, is in the R.A.M.C., and the youngest, Lieut. A. D. Pank, also a Sapper, was killed in France in 1915.

He was educated at Wellington College and the R.M.A., and was commissioned in the Royal Engineers on October 1st, 1913. His Y.O. course at Chatham was interrupted by the outbreak of war, and he sailed from England in October, 1914, with the 3rd Field Squadron, with whom he served, first under Sankey and then under Simon, until January, 1916. During this period he was twice wounded; the first time by a shell which burst on the road beside him and blew him over the hedge; the second time, while out wiring at night in front of the Hohenzollern Redoubt, by a bullet through the arm. As a result of the latter wound he was invalided home in January, 1916, and, though at the time he did not know it, left France and the Squadron for good.

For some time it was feared that he would lose his arm, but he made a good recovery, and in the autumn of 1916 was passed fit for service and joined the 65th Field Company at Salonika. He remained with them till the summer of 1917, when he was transferred to the 66th Field Company of the same Division as second-in-command. A few weeks later the Division was sent to Palestine to take part in the third and successful attempt to take the Turks' position covering Jerusalem.

A year's service on the Struma was a certain introduction to malaria, and in May, 1918, he had to go into hospital at Cairo. On his return, a month later, he was posted Adjutant to the 53rd (Welsh) Division R.E., where he remained till the Armistice.

While in Egypt his attention had been drawn to the possibilities of service in the Sudan, and in December, 1918, he went down to Khartum to join the Military Works Department of the Egyptian Army. After a short stay at Khartum he was sent to Malakal, on the White Nile, to carry out some building work, and while there he succeeded, by a lot of hard work and some little good luck, in bagging three elephants and three lions, as well as leopard, various buck, and other game, in less than six months.

In June, 1919, he was recalled to Chatham to join No. 3 Supplementary Class, and on its conclusion in December, 1920, returned to

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the Sudan, this time to Kassala, with a large visiting area round Gedaref and Gallabat. Here he got some more shooting, and also began to play polo, of which he became very fond.

After the war he had bought land in South Africa, at Addo, on Sundays River, thinking of retiring to farm there when his fifteen years' service for pension should be completed. In 1923 he spent his leave there, planting trees and making plans for the development of the farm; and in the summer of 1924, after a year at Fasher, in Darfur, he left the Sudan for good. He returned to England, and in September married Miss Meta Berent, a marriage which brought him happiness as great as it was to be brief.

With two years to serve before retiring on pension he was posted to command a Company of the Training Battalion at Chatham, but in the spring of 1925 he broke down and was sent on sick leave. His health had been undermined by recurrent malaria, in addition to his wounds, and by severe concussion, the result of a nasty fall at Khartum in 1921. During his sick leave, he and Mrs. Pank again visited his farm at Addo. He was then posted to Aldershot, but at once broke down again, and after a stay at the Osborne Convalescent Hospital was given leave until the date of his retirement.

He sailed for South Africa for the last time on August 13th, greatly looking forward to life on his farm. On the 9th September, a week after his arrival, he was taken ill, and died on the morning of the 11th.

Though still comparatively junior in rank, he had made his mark as an officer of the finest type that the Corps or the Army produces. Well-built and active, he was a good all-round athlete, playing, and playing well, cricket, rugger, polo, racquets, tennis and golf. He was an exceptionally good shot with both gun and rifle; the three lions which he killed in the Sudan were shot with an ancient .303 rifle, with which, in his own words, he had 'to aim a foot low and a foot right at a hundred yards,' and of which the ejector was broken. He appeared not only indifferent to danger but unconscious of it, and to be with him under fire was an ordeal to those of less steady nerves. Thorough himself in everything he undertook, he would never pass slovenly work by those under him. Humbug of every kind he detested. He was keenly interested in life, and read widely and deeply outside his profession. The last things he ever considered were his own advancement or his own convenience.

This very brief memoir has to fill the place of the two-volume biography accorded to men who have figured more prominently in the world's affairs; but it will be sufficient to recall to his friends an able and gifted officer, a gallant and selfless gentleman, and a most generous and loyal friend.

A.C.D.

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Captain Richard Durrell Pank, M.C., R.E.

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BOOKS.

" INONDATIONS."

Major R. Deguent, of the Belgian Corps of Engineers, Professor at the *Ecole d'application de l'artillerie et du génie*, has been kind enough to present to the Corps Library a multigraph copy of his "Cours d'Inondations," comprising text and maps. It forms a succinct manual of the subject. His lectures deal first historically with the inundations of the Belgian front in 1914-18, and then treat the subject of flooding an area theoretically from the point of view of hydraulics and the preparations and works required. The last two lectures show how a project for an inundation should be prepared and recorded, and work out a scheme for an inundation in the Senne valley above Hombeek.

In 1914, the drainage of the Yser area was in operation and the getting rid of surplus water was thoroughly understood; the converse problem of flooding it had not been considered. There were two distinct water systems: the first of the nagivable canals, the second, independent of the first, was the more complicated one of the " wateringues," " vaarts," or " fossés," a network of ditches designed to drain the area of rain or sea water, and at the same time to provide for irrigation of the " polders." As a rule the canals and the *wateringues* were connected at places by means of sluices, drop gates and weirs; sometimes the *wateringues* passed under the canals by siphons. The key of the whole system was the locks and sea-locks at Nieuport. One problem, when it was decided to let in the sea at high water, was how to keep dry the area behind the inundation, on which the Belgian Army and its communications were established.

Major Deguent gives a diary of the operations at Nieuport in October, 1914. The personnel of the *Ponts et Chaussées* had left the region, and it was the master lock-keeper, Cogge, in charge of the Furnes *Wateringue*, who provided the engineers of the army with the necessary information. An attempt on 26th October, 1914, to open the gates of the old Furnes canal, which enters the tidal Yser below Nieuport, was a failure; on the 28th, a second one succeeded; but, owing to the smallness of the channel, the result of three tides was " presque nul." It was therefore decided to open all the sluices of the weir of the Noordvaart, the principal evacuation channel, and this was done by an engineer detachment, covered by a party of cyclists, on the night of the 29th at 7.30 p.m., and the sluices closed again at 1 a.m. at low water. This manœuvre had to be repeated under fire at each tide until the night of the 1st November, by which time the inundation required was definitely established.

The Blankaart and Knocke inundations, nearer Ypres, are also described; but there is no reference to the " pump ships "—barges with pumps—stationed by the British at Fintelle Lock in summer, to raise water from the sea inundation to that of the next level, in order to maintain the flooding there. Nor is there mention of the six great pumps established at Dunkirk, so that sea water could if necessary be pumped to supplement the inundations at all times of the tide. Descriptions of these installations will no doubt be found in the " Miscellaneous " volume of " Work of the Royal Engineers in the European War, 1914-1918," now in the press.

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The next lectures considered the theory of the subject, and provide all the formulæ required as regards flow of water, tides, etc.

The general conclusions to be drawn from the Yser inundations are :—

(1) In order to avoid delays, mistakes and failure, the hydraulic system of the region to be inundated must be thoroughly known (ground, works—canals, locks, bridges, etc.—relations between the various works, possible effects of any water manœuvres).

(2) To assure rapidity of execution, there must be thorough preparation in time of peace, and a permanent *dossier* containing all the information required for creating the inundation.

(3) There must be a geological examination of the ground, not only from the point of view of making the inundations, but the retention of the water in the area.

(4) The inundations having been created, the work of maintaining them, and guarding against enemy operations against them, must be taken in hand. These include :—

Constant watch on the level of the inundation and the works that maintain it (gauges and inspection) ;

Precautions against damage, whether by floods, bombardment or enemy operations (doubling important barrages, reinforcing banks, etc.);

Provision against any manœuvre or incident which might modify the level of the water.

(5) The technical work required for the creation and maintenance of an inundation is considerable. There is a perpetual struggle to prevent the failure of the banks and lock sills and walls, owing to the increase of the velocity of the current during formation of the inundations and water manœuvres that follow it. On the other hand, reduction of the velocity leads to channels silting up. The arrangements of peace conditions seldom provide for the above.

The "dossier" or records should include:

(*a*) Maps (generally 1:10,000) showing the works available to hold up water and barrages required, the area covered by inundation at various levels, the sites of the works either used or constructed to form the inundation, and the railways and roads ;

(*b*) Plans of all the above works ;

(*c*) The *Mémoire* containing a general description of the ground and the works, an account of the various inundations that can be formed, justification for the choice made ; the measures required to be undertaken ; a schedule of the work to be done in time of peace and in time of war on receipt of the order to prepare to make the inundation, and during the formation of it ;

(*d*) Detailed tables of work (order of urgency, material and time required) under the above schedule, for the maintenance of the inundation ; summary of personnel, material and tools, and tables of the times required to form the inundation to various levels at various seasons of the year. The effects of evaporation and infiltration must not be overlooked.

(*e*) Orders and instructions for the personnel.

It might have been added that what the Commander-in-Chief will want to know is: How much inundation can I have in one day, two

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days, a week? What communications will be affected? Can I use the roads in the inundated areas, say, on the third day, will they still carry heavy traffic? J.E.E.

SOLDIERS AND STATESMEN, 1914-18.

By Field Marshal Sir William Robertson, Bart., G.C.B., G.C.M.G., K.C.V.O., D.S.O. (Cassell, 2 vols., 1926.) Price £2 10s. 0d.

During a round of golf five years ago, Sir William Robertson, ignoring for once the principle of concentration, broached the subject of the propriety of soldiers and statesmen writing their reminiscences of war. He judged that it was as well that they should do so, for otherwise much information would be lost and the true history of a war would never be written.

In his preface, he states why he feels justified in using information which he acquired in the course of his career as a public servant and which, under other circumstances than those of the Great War, might be regarded as too confidential to be published. "The present book," he says, "deals with events none of which are less than eight years old, and so far as it may be held to disclose documents or discussions which were once classed as confidential, it cannot, I think, injure any public interest now existing. On the contrary, to place on record for the guidance of future generations of soldiers and statesmen the experiences gained in the first war in which the General Staff, as such, took part, should be to the benefit, not to the detriment, of the State." The author's opinions are not written "after the event," but are fully substantiated by memoranda written by himself, or by the G.S., at the time.

To attempt to review a book written by a past-master of conciseness, is, to say the least, difficult; the reviewer can only quote from the author's account of the conduct of the war and call attention to his considered opinions on, and reasons for, the action that was taken.

Sir William Robertson was Chief of the Imperial General Staff from December, 1915, to February 26th, 1918. None of the four other officers who occupied the post during the war held it for more than a few months; three of them are dead. Few men have the stamina to undergo the tremendous strain of such an office in the stress of war. Sir William held it for over two years, and those years covered the period in which the issue of the struggle was always in the balance. Trained to hard work, he had to face more than hard work in London. The responsibilities of Q.M.G., and then of C.G.S., of the B.E.F. in France during 1914-15, were comparatively child's play. At the War Office he had to battle with Ministers—all experienced politicians: some, men of outstanding intellect. Unfortunately few, if any, had any deep knowledge of military affairs and the conduct of war.

Like his right hand man and Director of Operations, Sir Frederick Maurice, in his recently published book, "Governments and War," Sir William Robertson reminds us of the warning given by the late Lord Salisbury in 1900, as to the unsuitability of the British Constitution for war purposes; how that warning remained unheeded; and how it had occurred to no one in authority that the organization of peace would have to be completely changed in time of war. The two

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books are complementary to each other, but the C.I.G.S. should be read first. The importance of the human factor, not only within the staffs and High Commands, but also between the governments, of allied nations, cannot be underestimated, and both writers have earned our gratitude for drawing attention to this important matter.

General Maurice has told us how in the American Civil War both Lincoln and Jefferson Davis had to learn much about military affairs, from McClellan and Grant on the one side, and from Lee and Johnston on the other. So had Mr. Lloyd George to learn from his C.I.G.S. in 1916. Both Lincoln and Davis frequently made suggestions as to plans of action to their military advisers in the later stages of the Civil War, but they did not persevere with them when those advisers proved them to be unsound. They dropped them once for all. Not so Mr. Lloyd George. He sometimes gave way, it is true. But even if he dropped the proposal for a time, he took the earliest opportunity to revive it and to attempt to upset or modify a decision to which he had already given his approval. It required a disaster of the first magnitude to teach him to leave military affairs to be dealt with by military experts. Sir William Robertson's book gives example after example of his failure to grasp the essential principles of strategy. The obvious deduction is that he distrusted his military advisers, and, instead of changing them at once, allowed himself to listen to all sorts of advice and suggestions from irresponsible officers and others.

It is Sir William Robertson's opinion that :—" The war afforded no confirmation of the view sometimes held that the War Minister ought to be a professional soldier. On the contrary, Lord Kitchener's occupation of the post showed that the appointment of a soldier, especially of very senior rank, must necessarily be attended, both at Government headquarters and at the front, with certain disadvantages which it is desirable to avoid. The country undoubtedly gained more than it lost by having had Lord Kitchener at the head of the W.O. ; and most people will agree that no one else could have raised, or would have thought of raising, the great armies, without which, humanly speaking, victory could not have been secured. But Lord Kitchener was an exceptional man." It will be remembered that the author refused the position of Secretary of State for War, and a peerage, which were offered him by Mr. Lloyd George in 1916, on his becoming Prime Minister.

In Chapter I, the development of the Expeditionary Force is traced from the time of the Cardwell reforms in 1870-1 up to 1914. In referring to the second attempt to improve matters, in 1888, he mentions the somewhat laboured objection of Sir Henry Campbell-Bannerman, one of the members of the abortive Hartington Commission of 1888-90, to the creation of a " Chief of the Staff," though he concurred in the abolition of the office of " Commander-in-Chief." As a consequence, there is no doubt that Lord Wolseley, before the South African War, must have been greatly hampered by being deprived as he was, of the powers which as Commander-in-Chief, he was entitled to possess, and which his predecessor, the Duke of Cambridge, did possess but did not exercise.

Sir William Robertson states his opinion—though he does so with great regret—that Lord Roberts, on becoming C. in C., missed a great

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opportunity after the South African War for getting matters placed on a more efficient footing. "Lord Roberts must be held accountable, no less than the Government, for the small progress in reform accomplished after the South African War. The efforts which he subsequently made (about 1906-7 and later) to introduce military training, unfortunately lost something of their weight because he had made no such recommendation to the Government when C. in C. and in a position to press officially for its acceptance." But there was another reason, which did not exist in 1902, and Sir William Robertson quotes Mr. Asquith, Lord Grey and Mr. Haldane in support of it. "From 1908 onwards it was considered too dangerous by the Government to adopt a new military system which would have taken some years to build up. The temptation to a foreign General Staff to make an early end of what it might insist on interpreting as preparation for aggression on our part would be too strong to be risked."

After discussing the relative responsibility of statesmen and soldiers for our unpreparedness in 1914, and giving his view on the question whether soldiers should resign if their advice is not followed by Ministers, Sir William Robertson concludes the chapter with the following words: "From whatever angle their action is viewed, those soldiers who held the office of Army councillor in the years preceding 1914 were, no less than the Ministers, accountable for the inadequacy of the means with which the Great War was begun."

Chapter II, "The Western Front, 1914-15," commences with the sentence: "The policy to be adopted in the circumstances—what British policy was likely to be should Belgium be invaded by either belligerent, in the event of war between France and Germany—must necessarily be settled by the Government of the day when the time comes. It cannot be decided now. All that can be said now is that the fulfilment of our treaty obligations will follow, and will not precede, the national inclination." Such was the reply of the P.M., the late Lord Salisbury, to a W.O. Memorandum (written by Colonel Robertson, as he was then) in the year 1902. Col. Robertson cannot be accused of want of foresight.

From 1910 onwards, when Germany's aggressive designs had become more pronounced, and our relations with France and Russia had been put on a more friendly footing, the difficulty of supplying the information asked for by the W.O. in 1902 should have been less, while the need for supplying it was certainly greater. "But," writes Sir William Robertson, "it was not supplied. . . . In other words, we were without the means required for enforcing the policy in which we had become involved. . . . The French were, consequently, forced to frame their plan of campaign not knowing whether they would or would not receive British assistance, while we on our side were not able to insist upon our right to examine the French plan in return for our co-operation. When the crisis came, there was no time to examine it, and our military policy was for long wholly subservient to the French policy, of which we knew very little." There was a divergence of views at the very start. Lord Kitchener thought our position at Maubeuge would be too exposed, and he favoured a concentration further back in the neighbourhood of

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Amiens. But he felt obliged to yield to the opinion of the combined French and British staffs, some members of whom had studied the subject in conference unofficially for several years. Lord Kitchener proved to be right. Before the B.E.F. fired a shot, the question of a change of base had to be considered, owing to the Line of Communications to Boulogne and Havre being threatened, and on Aug. 27th the order had to be given by the Q.M.G. (Sir William Robertson) to transfer the main base to Nantes, further south and west. This was only possible thanks to our assured naval supremacy, and the author considers that all we had ever spent on obtaining that supremacy was more than justified by the fact that we were able to effect the change of base without interference.

Sir William Robertson, as Q.M.G. of the B.E.F., has naturally a good deal to say about the shortage of gun ammunition throughout the autumn and winter of 1914-15. He lays particular stress on the paralysing effect which uncertainty as to ammunition supply had on plans for operations, and mentions the fact that while operations were in progress, in May, 1915, 20,000 rounds had to be sent to Gallipoli, showing that secondary offensives were already beginning to affect operations on the decisive front. The question of the policy to be followed in the following year (1916) was discussed at a joint Conference at French G.H.Q. at Chantilly as early as June, 1915. The British Government was in favour of remaining inactive on the Western Front in 1916, presumably to give time for the development of the New Armies and the supply of munitions, but the proposal was promptly rejected by the French, and the decision arrived at was :—" A passive defence is out of the question, because it is bad strategy, unfair to Russia, Serbia and Italy, and therefore inadmissible." Was it only the losses in the Second Battle of Ypres and our premature commitments in the Dardanelles and in Mesopotamia, that caused the British Government to put forward the proposal ? Or, was it visions of a great Balkan campaign as our main effort, against Austria, and the simultaneous landing of 100,000 British soldiers " in Syria " to cut off the 80,000 Turks said to be advancing from there on Egypt, that prompted it ? Sir William Robertson refers more than once to the famous memorandum produced by the Chancellor of the Exchequer on Jan. 1st, 1915, proposing these eccentric campaigns, to enable which to be carried out he also proposed to transfer the whole B.E.F., with the exception of a general reserve to be left in the vicinity of Boulogne, from France to Macedonia and Syria. " These proposals found no favour with the French. Moreover, the safety of France, and of the Channel ports in particular, was vital to us."

This opportunity may be taken of stating that Sir William Robertson deals summarily of Lord Fisher's scheme for making a combined naval and military attack on the coast of Schleswig-Holstein. " This plan," he says, " had often been mentioned before the war, and as often rejected. From a military standpoint it was not a practicable proposition."

Chapter III. " The Dardanelles Expedition." As C.I.G.S., Sir William Robertson had only to deal with the evacuation of the Peninsula, and he relies chiefly on the Report of the Dardanelles Commission for his information. But what he has to say is extremely valuable,

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and should be read by all who wish, or have, to study the campaign, for it may save them wading through the Commission's Report.

In Chapter IV, " War Organization," we find a most valuable document, in the form of a letter written to Lord Kitchener, and at his request, on Dec. 5th, 1915, in which the C.I.G.S.-designate gives his views, after preliminary discussion with the Secretary of State, on the status and duties of the C.I.G.S. (Vol. I, pp. 168-170). The Memorandum necessitated a change in the Order of Council of 10 Aug., 1914, but the suggestions therein set forth were adopted in their entirety within a year, and resulted in military responsibility for the whole Empire being centralized in the War Office alone. Its provisions were unreservedly accepted by Mr. Lloyd George when he became Secretary of State for War. At the time, Mr. Lloyd George said that no Minister was likely, and certainly not himself, to wish to alter it during the war. Nevertheless it was Mr. Lloyd George who, as Prime Minister, altered it on February 11th, 1918, in the Note (see Vol. II, p. 232) in which he virtually dismissed Sir William Robertson. Pages 174-8, Vol. I, should be read in this connection.

One of Mr. Lloyd George's first acts, and one of which Sir William Robertson thoroughly approved—he always gives the Prime Minister full credit for right decisions—was to replace the traditional Cabinet of about a score of members by a " War Cabinet " of five. It formed, together with the naval and military chiefs as advisers, the Great General Headquarters of the Empire. The French copied the organisation in 1917, when they formed a Great General Headquarters at the capital, with a Chief of the General Staff (first General Pétain and then General Foch) to carry out duties similar to those which devolved on the C.I.G.S. of the British Army. Pages 168-190, Vol. I, on the working of the organization are some of the most instructive in the book.

Chapter V. " Unity of Command." Co-operation, in the earlier stages of the War, was obtained on the basis that France was the predominant partner of the Entente. Plans were co-ordinated by means of conferences between the military chiefs or their representatives. The results achieved were not completely satisfactory. The next development was a system of regular ministerial conferences, but as their function was civil, not military, it was suggested by the French that a Combined General Staff should be formed, with General Foch as C.G.S., with a view, perhaps, of his some day developing into a Generalissimo of the Allied Armies. Both the P.M. and C.I.G.S. were opposed to the idea of a Generalissimo, but before the French proposal could be discussed, the Italian disaster at Caporetto led to a Conference at Rapallo in November, 1917, at which it was eventually decided to form the " Supreme War Council." The Premiers of the Great Powers fighting on the Western Front were to be members, with a subordinate Minister from each country ; and there were to be " military representatives " whose function it was to advise. Here was the crux—they were to advise over the heads and independently of the Chiefs of the General Staffs of the Armies. These military representatives were to form an " Executive Committee " to take charge of the handling of the reserves of the several armies and co-ordinate their disposal.

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The "Executive Committee" completely broke down when put to a practical test at the end of March, 1918, and on the 26th General Foch was appointed virtual, and three weeks later, actual Generalissimo of the Allied Armies.

As to the necessity of that appointment, in the circumstances, Sir William Robertson agrees, but he points out that, however successful the result proved, there was no guarantee that it would have been justified, say a year before—in view of the opposition of Mr. Lloyd George, who had declared in the House of Commons the appointment of any Generalissimo "would lead to real friction, and might produce not merely friction between the Armies, but friction between the nations and Governments."

Chapter VI. "The Western Front, 1916." The Allied General Staffs had no difficulty in agreeing as to the probable course of events during 1916, but the Ministers were somewhat divided. The French government was still in favour of strengthening the Salonika armies in the hope of bringing in Rumania, and they were also listening to somewhat frequent suggestions from Russia in favour of an advance in strength through the Balkans. However, the policy agreed upon was to expect a powerful German offensive on the Western Front, and to be prepared to take the offensive energetically, on a properly co-ordinated plan, on all three main fronts. The German assault was launched on Feb. 21st, 1916, on Verdun, where it was expected, but the early date came somewhat as a surprise.

Sir William Robertson thinks that, with the exception of a much larger detachment than necessary in Macedonia, where the Anglo-French armies amounted to 200,000 men, the principle of concentration in the decisive theatre had been well observed during the winter of 1915-16.

The objects of the Somme Campaign were, firstly, to ease the pressure on the French at Verdun; secondly, to give relief on the Russian and Italian fronts; and thirdly, to wear down relentlessly the German armies on the Western Front.

The operations lasted from July 1st till the middle of November, when they were stopped by bad weather.

As to the results, Sir William Robertson states that the General Staff agreed with General Haig in considering that the three objects of the campaign had been achieved, and that the enemy had been dealt a staggering blow from which he would find it very hard to recover. But they were of opinion that there was still much to be done before his final overthrow could be accomplished. The consideration of these further measures was immediately taken in hand by the General Staff. First and foremost was the question of Man-power.

This question is dealt with in Chapter VII. Ministers had always approached the question of universal service in a half-hearted manner. It can, perhaps, be understood why the proposal was rejected in August, 1914; when there had not been time to prepare a scheme—belated as it would have been—but that reason did not hold good later. The policy of National Service was actually accepted in principle towards the end of Mr. Asquith's tenure of office in 1915, and it had been hoped to pass

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the necessary legislation before the end of the year. But within a week Mr. Asquith had resigned, and the question was again shelved by Mr. Lloyd George. From 1916 onwards, the necessity for universal service was frequently urged by the soldiers. Various make-shifts were tried, but it was not till the disaster to the Fifth Army in March, 1918, that the principle was put fully into practice.

Chapter VIII. "Home Defence." On the whole, Sir William Robertson is of opinion that the number of men retained in this country for Home Defence was not excessive.

The question of whether invasion was possible or not depended naturally on the Admiralty.

In August, 1914, two regular divisions were held back temporarily, so as to give the Territorial troops more time to get into their places. The later dispatch of Territorial troops to the front was made subordinate to the retention of an adequate number at home, and although this policy was slightly modified during 1916-17, after Jutland, and when the Americans entered into the War, the requirements of Home Defence continued to take priority over the reinforcement of the armies abroad, until the great German offensive in March, 1918.

Sir William Robertson mentions the effect of the air raids, which caused us to withdraw temporarily two squadrons from France and permanently to retain one. In concluding the chapter, Sir William Robertson says: "The attitude of Ministers responsible for protecting the homes and lives of the people is easy to understand, and attention is drawn to it, not by way of criticism, but in order to emphasize the fact that when war is afoot the requirements of Home Defence, whether on land, on sea, or in the air, will, except perhaps in the case of a great crisis, such as that which occurred in March, 1918, invariably have to be given precedence over requirements connected with operations abroad."

Chapter IX. "The Mesopotamia Campaign." This chapter, based on the Report of the Commission on its conduct and on the Official Account, is of great value to all officers who may have to study the campaign, and of special value to those interested in staff duties.

As regards the strategy, Sir William Robertson, whose experience of India and the East is by no means superficial, says:—"From first to last, both in London and India, the advantages to be derived (from the occupation of Baghdad) were over-rated, and were too often allowed to obscure the practical difficulties (chiefly of communications) that stood in the way of their attainment."

Lord Kitchener was opposed to the project from the beginning. But permission was given for General Nixon to march on Baghdad if that officer was "satisfied that the force he has available is sufficient for the operation." The Home Government thus placed on General Nixon the sole responsibility for deciding whether the scope of the campaign was or was not to embrace the capture of Baghdad—an operation which the Viceroy had said would "probably determine the Turks to send large forces to attack us." . . . "To the layman it may appear that as Nixon was left with a free hand, he had only himself to blame for what followed, and to some extent that must be admitted. But there was much to be said on the other side, for the question was not merely one of going to

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Baghdad, or even of remaining there. Much wider issues were involved. The question was essentially one of policy and general strategy, and not merely one of tactics. Therefore it was beyond the power of any local Commander properly to decide. Moreover, Nixon was without good information either as to the probable strength of the enemy's reinforcements or the date of arrival of his own."

The disaster of Kut led to the control of the operations being vested in the General Staff, but administrative control was left to India. It was not till July, 1916, that both administrative and operative control was taken over by the War Office, and it was not till then that "the railways were really pressed forward with the vigour which the situation demanded (Mesopotamia Commission Report)."

" Supreme responsibility," says Sir William Robertson, " for the two functions of operations and administration ought, in fact, never to be separated, and it was a mistake on my part not to have asked for War Office control of both at the same time (Feb. 3rd, 1916)."

His final criticism on the campaign is as follows :—

" Considered as a military measure, and in its relation to the war as a whole, the campaign greatly exceeded in scope the requirements of the situation, and left us a legacy of increased military responsibilities of which the full consequences cannot yet (1926) be seen. . . ."

Chapter X. " The Salonika Expedition." The only possible arguments in favour of our going to Salonika were (1) the moral obligation to help Serbia—as we helped Italy in 1917—an ally in distress, and (2) the denial of the littoral as a submarine base for our enemies.

The first miscalculation was the failure of Greece to fulfil her treaty obligations to go to Serbia's assistance. Next, Serbia was invaded before she could be supported, by some 200,000 Austro-German troops from the north and by the Bulgarian Army of 250,000 men from the east, and within 2 months was overwhelmed.

Sir William Robertson, in his narrative of what happened subsequently on this front, gives General Sarrail credit " for preventing any movement of Bulgarian troops northwards during our Somme Offensive in 1916. Admittedly Sarrail was in a very difficult position.

" Firstly, the indecision of Rumania and the persistent endeavours of France to bring her into the war led to his receiving many perplexing orders and counter-orders, entailing constant changes in his plans. Secondly, affairs in Greece were in such a state of chaos that he never knew from hour to hour what policy the Entente Governments might adopt for dealing with the situation."

Rumania eventually entered the War, but the three months' delay in making up her mind had been fatal. Moreover, her strategical dispositions at the outset of the campaign were faulty and seemed to incite defeat. When matters came to a deadlock on the Salonika front and Mr. Lloyd George began to realize that no benefit, political or other, could be derived from them, he apparently ceased to take interest in them, but it was not till the spring of 1918 that all efforts were concentrated on the object of main importance—the defeat of the German main armies—and a considerable reduction made in the Salonika army.

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Chapter XI. "The Campaign in Palestine." Sir William Robertson considers that the operations directed against the Turkish forces based on Palestine were, in their early stages, both appropriate and profitable, in that they helped to secure the Suez Canal. Later, they became objectionable, for they absorbed troops which ought to have been sent to the Western Front.

As regards the defence of Egypt, Lord Kitchener was in favour of indirect defence, his idea being that we should operate from Alexandretta, making use of the troops to be withdrawn from Gallipoli. But the Alexandretta project had already been considered and turned down. The combined staffs, therefore, decided that Egypt must be defended by direct methods, and in Sir William Robertson's opinion, the conclusion was sound from every point of view. He incidentally mentions a project, which was fundamentally unsound and fortunately did not materialize, namely, the proposal to send a force to Rabegh, a place on the Red Sea coast between Jeddah and Yambo, in order to support the Sherif of Mecca and the Arab revolt against the Turks.

In Palestine Mr. Lloyd George hoped to gain the dazzling success which had been denied to him in the Balkans, and he did all he could to persuade the General Staff to get matters pushed there, first by Sir Archibald Murray, and then by General Allenby. The latter was taking no risks, and his estimates of troops required was so discouraging that his mission was limited "to defend Egypt and by such offensive action as he deemed feasible, compel the enemy to divert to Palestine troops that might otherwise be used against General Maude in Mesopotamia." The wisdom of this policy was demonstrated. A week or two after it had been laid down, five British and five French divisions had to be withdrawn from the Western Front to assist the Italians after Caporetto. It was not till September, 1918, that General Allenby was able to commence the advance, which resulted in the overthrow of Turkey's military power in Asia and the occupation of her territory up to and including Aleppo.

Chapter XII. "The Western Front, 1917," deals with the operations on the Western Front subsequent to the Battle of the Somme.

On November 15, 1916, that is, during the Battle of the Ancre, an important conference took place at Chantilly to decide upon a plan of campaign for 1917. It was agreed that the plan should be of a decisive character, and that it should comprise a series of offensives on all fronts to commence not later than the middle of February. The French were late with their preparations, whereby much of the advantage gained on the Somme was lost, while the revolution in Russia, beginning in March, made a simultaneous offensive on all fronts impossible.

During a conference held at Rome early in January, 1917, "the Prime Minister surprised all present by producing a plan for a combined French-British-Italian offensive through the Julian Alps to Laibach and Vienna, the object being to put Austria out of the war."

Who drew up this plan? The British C.I.G.S. says that the British General Staff had previously heard nothing about it, and none of the other Entente staffs had any knowledge of it.

The French took no risks. On the way home, the British and French

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delegates were met at a railway station near Paris by General Nivelle, who had just succeeded Joffre as C.-in-C. He came to ask the co-operation of the British Government in another plan, the one which he proposed to substitute for the Chantilly plan (backed by Joffre). It is unnecessary here to go into the Nivelle controversy: Sir William Robertson gives a detailed account of it which amplifies what is generally known about it. The British attacked at Arras and Vimy on April 9th. The French offensive further south failed, and matters were further complicated by the mutinies in the French Army, of which, fortunately, little or nothing was heard at the time in England or on the British front. By June 20th, General Pétain was reported to be satisfied that he now had the trouble well in hand, and although Mr. Lloyd George once more brought forward and pressed strongly his Austrian scheme, it was decided to persevere with the original plan and transfer the main offensive to Flanders in the autumn and endeavour to clear the Belgian coast. Eventually, on July 31, 1917, the British Second and Fifth Armies attacked on a broad front, with limited objectives. The writer can well remember standing in the rain at 2 p.m. on that day in the trenches captured by his Division, in a very limited objective on the extreme right of the battle front, and discussing with his G.S.O.1. (Dill) the disastrous effect of a downpour of rain at this juncture if it persisted. It did persist, and August, 1917, had the worst rain record for many years.

Sir William Robertson says with regard to Paschendaele that: "The decision to persist with the operations has been widely criticised, and it may be said at once that responsibility for the error, if error there was, must be shared by the Imperial General Staff, since it was their duty, in communication with G.H.Q. in France, to call a halt immediately that course became advisable. . . . But there were strong reasons why activity had to be maintained. We had to give the French Armies time to recover their strength and morale, make every effort to keep Russia in the field in some form or other, and try to draw enemy troops to Flanders which might otherwise be sent again to Italy, especially after her defeat at Caporetto. All these purposes of distraction were achieved, and in addition heavy losses were inflicted upon the German armies."

Chapter XIII. "Preparations for 1918." The first question was whether we should aim at finishing the war in 1918, or defer the attempt until 1919. "The answer to this," says Sir William Robertson, "was easier to give than to apply. Obviously we should, if we could, defer the attempt until America was ready. But could we defer it?"

The answer which he gave to the War Cabinet is contained in a memorandum given on p. 269, Vol. II, which ends with the following sentence: "I therefore submit that the only practicable thing to do is to make ready to the full extent of our power by the early spring and decide then to what extent we should fight." He laid stress on the point that a defensive policy in the distant theatres was particularly to be desired because it would enable American troops to be brought to France with greater rapidity.

That Germany intended to prevent us deferring our effort to 1919

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became more and more certain during the winter. The War Cabinet could not, or would not, see the seriousness of the shipping position. If they had done so they could not for a moment have countenanced, as they did, the Palestine project, again revived by Mr. Lloyd George.

On February 1st, 1918, at a meeting of the Supreme War Council, the "technical advisers" reported, after many weeks of delay, and recommended that "subject to the Western Front being made secure" a decisive offensive should be undertaken—against Turkey, with a view to the annihilation of the Turkish armies and the collapse of Turkish resistance.

Before putting the resolution to the meeting, the chairman asked if anyone present wished to offer any observations on it. The British C.I.G.S. made the following statement: "It is not for me to approve or to oppose any resolution of the Council as I am not a member of it, but as I have been summoned to attend, I feel compelled to submit, in view of the state of the Entente's resources, especially in men and shipping, and of possible events on the Western Front this year, that the Council ought to adopt a defensive policy in all secondary theatres, and to keep no more troops there than are necessary for that purpose. I am also of opinion that to undertake the campaign in Palestine as recommended by the technical advisers of the Council is not a practical plan, and to attempt it will be very dangerous and detrimental to our prospects of winning the war." No one else appears to have spoken.

M. Clemenceau then suggested that the Council should take note of the objections raised by the C.I.G.S., British Armies, and asked whether they involved any modification of the resolution. Mr. Lloyd George said that he still adhered to it, and as no one else had any further remarks, it was accepted.

When the C.I.G.S. expressed his regret to the P.M. for having opposed his plan before the foreign delegates, and explained that if he had said nothing they might have thought he had no objection to offer, "Mr. Lloyd George angrily disagreed, saying that, as I had already acquainted him with the General Staff's views, there was no necessity to repeat them before the Council." It will be remembered that before the Dardanelles Commission, a year or so earlier, Mr. Lloyd George agreed with the Commissioners that if naval and military advisers present at Ministerial Councils did not express dissent, it was legitimate to assume that they agreed with what was being done, (pp. 286-7, Vol. II). Sir William Robertson submits that naval and military officers holding the position of professional advisers to the Government ought not to be deterred by these or any other considerations from plainly stating what they think. "Of course, they must do all they can to cultivate good relations with their ministerial masters, and endeavour to meet their wishes, but, when a state of war exists and men's lives are at stake, they will be disloyal to their country if, knowing that a plan is bad, they do not speak and condemn it." "Napoleon is credited with having said: "*Tout Général en chef qui se charge d'éxecuter un plan qu'il trouve mauvias, est coupable. Il doit réprésenter ses motifs, insister pour que le plan soit changé, enfin donner sa démission plutôt que d'être l'instrument de la ruine de ses troupes.*"

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In conclusion: the reviewer craves indulgence in that time does not permit of a further effort to condense this attempt to give the readers of the *R. E. Journal* a fore-taste of the distinguished author's valuable and intensely interesting work. He ventures to hope that, as there are so many of his brother Officers, serving and retired, at home and, more particularly, abroad, who will wish to read the book as soon as they can get hold of a copy, this humble attempt at a review, too lengthy though it be, will serve to whet their appetite. They will never regret it, even if they have to present themselves with the volumes. The author's "From Private to Field Marshal" is, and will long be, a favourite gift book to the boy who wants to be a soldier. So "Soldiers and Statesmen" will always be an acceptable present to the man who aspires to be a Field Marshal, or a Prime Minister.

H.B.-W.

IMPERIAL DEFENCE, 1588-1914.

By COLONEL J. F. C. FULLER, C.B.E., D.S.O. (Sifton Praed & Co., Ltd., 1926). Price 3/6.

A timely and instructive volume of a hundred pages, in which the author traces the growth of Imperial Defence from the sixteenth century to the Great War.

He manages to bring into it an account of the Holy Alliance and the inevitable comparison between it and the League of Nations. Of the futility of the latter he is in no doubt. He ends with an appeal to substitute for it a League of British Nations, which will set the Empire on a securer footing than ever before.

In the opening chapter, Colonel Fuller enunciates the principles on which he believes that the British Commonwealth has been built up, namely—

(1). The establishment of domestic peace in the first instance in Great Britain after the union with Scotland (1707), and, later, in the several British oversea possessions.

(2). The maintenance of the balance of power in Europe.

(3). The establishment of secure frontiers, again in the first instance in Great Britain, and subsequently in our colonies.

(4). The maintenance of the Command of the Sea.

(5). The self-government of self-controllable Colonies.

In Chapter II, the author traces the childhood of Imperial Defence. Its birth he dates to the time when "after the union with Scotland the entire frontiers of the realm became surrounded by the ocean and an all but un-attackable frontier was gained. Nearly contemporaneous with the establishment of this boundary the instinct of expansion urged the English beyond their shores. Expansion prevented decadence, it enabled hostile minorities to escape from tyrannical majorities, it supplied a vent for adventurers, those truculent hunters after Eldorados, who, if forcibly kept at home, revolt against their surroundings.

"This expansion carried with it, as a necessity, command of the sea, which, in the Dutch Wars of the seventeenth century, passed to England, and has ever since remained an instrument of peace in the hands of the British nations.

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"With the growth of sea power, which alone cannot guarantee the integrity of oversea possessions, there developed from the time of the first great Imperialist, Oliver Cromwell, the theory that international war may be restricted by the institution of a balance of power between civilized nations and that international peace can best be maintained by a majority of nations, which through preparedness for war and threat to use physical force, keep in check the aggressive tendencies of a would-be aggressor.

"From Cromwell's time to the present, the maintenance of the balance of power, therefore, formed the keystone of British foreign policy, except for short periods of pacifity which have invariably been followed by international conflicts. But though the maintenance of the balance of power between the nations of Europe has guaranteed the integrity of the Empire as a whole, it was unable to secure distant portions of the Empire against local attack. The consequence was that the instinct of expansion in our oversea possessions forced them to push out their frontiers to impassable obstacles. Separated by sea from her colonies, the Home Government has never been able to impose its will on our oversea possessions, the only attempt to do so resulting in the loss of our American Colonies. The impossibility of exerting control based on physical force has resulted in our having to maintain alliance by means of sentiment. Herein lies the cohesive force which holds the Empire together—very different to that found in all preceding Empires, which have been held together by tyranny, by federalization or by confederalization. The British Empire as we see it to-day, is actually a family partnership held together, as every family is, by a bond of family-preservation and sentiment, preservation not only of the family as a whole, but of the family as the inheritor of traditions, customs and a literature which it is considered honourable to maintain because they have proved their worth.

"The supreme test of the British Empire has been, in the past, not the disruptive but the consolidating effect of foreign wars. Every great foreign war has given new lease of life to the intricate partnership which, for over two and a half centuries, has succeeded in reconciling 'diversity with uniformity.' The secret of the success of the British system of rule is that it has tended its colonies in infancy, and freed them on coming of age. It has, in fact, reconciled security and liberty in a manner totally unapproached by any former empires."

The author goes on to give an outline of British history and of the growth of her sea power, to the fall of Napoleon. From 1815 to 1874, Colonel Fuller considers that there was a period of decadence. He attributes it to the effects of the sufferings consequent on twenty-two years of war. He says :—"European politics lost all vision, and a period of dementia supervened. The statesmen of Europe congregated together to seek a national solution of international problems. The cure proposed was none other than that of a League of Nations called the Holy Alliance, from the faults and failures of which every European war since the Congress of Vienna (1814), may be traced."

England did not subscribe to the Holy Alliance. Its failure Colonel Fuller attributes to the fact, common to both the Holy Alliance and to

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the League of Nations, that they are essentially communistic and consequently unpractical and dangerous. "The Holy Alliance," he says, "was in fact a conspiracy against popular liberty, consequently a standing irritation."

Though renewed in 1833, but only by Russia, Austria and Prussia, the Holy Alliance died a natural death in the early fifties. In 1854 England went to war with Russia, and then followed the Indian Mutiny. There was then a temporary recrudescence of military fervour in Great Britain, and, in 1859, a Committee was appointed to consider the cost of the military defences of our Colonies. The result was the recognition of the principle of Imperial partnership by Mr. Gladstone, which led to the Colonies undertaking their own defence and so permitting the regular garrisons being gradually withdrawn. The renaissance of Imperial Defence dates from 1875. In 1879, a Commission was set up to enquire into the defence of British possessions and commerce abroad. In 1885, a standing Colonia Defence Committee was created.

The first Colonial Conference took place in 1887, Queen Victoria's Jubilee year. It is memorable as being the first occasion on which defence was brought prominently before the Colonial Governments as the most important "common interest" and "common responsibility" of the mother Country and daughter States.

Colonel Fuller traces the course of our foreign policy throughout the period and shows how, when the South African War broke out, England stood alone in the world completely friendless, and as an Empire totally unprepared to wage a war even against "embattled farmers." He has a dig at the system of conducting war which led to our troubles in that campaign, and hits the nail on the head when he quotes Colonel G. F. R. Henderson's "The Science of War," on the subject. The reference awakes one's regrets at the fact that perhaps not a single copy of Col. Henderson's printed draft for the political chapter for the official History of that war now exists. Every copy was ordered to be destroyed. One copy survived for some years, but that has now disappeared.

Henderson pointed out that up to this period Imperial Defence had never been approached from the standpoint of Imperial strategy. But good came out of evil, for the South African war was a war of Imperial education. It demonstrated that the Empire did exist, and that it intended to continue to exist as a united brotherhood in arms should its frontiers be threatened.

We now reach the period of the Reformation of Imperial Defence. The South African War awakened the Imperial spirit amongst the peoples of the Empire. The Colonial Conference held in 1902 was notable from both a naval and a military point of view, for the Canadian Premier announced that the Dominion contemplated the establishment of a local naval force, and Mr. Seddon submitted a resolution suggesting the formation of an Imperial Reserve Force in each Dominion for service, in case of emergency, outside the Dominion or Colony, the cost to be shared between the Imperial and Colonial Governments. Though the resolution was not accepted by all the Dominions, New Zealand had pointed the direction in which the defence of the Empire was to be sought, and her action was not wasted. Shortly afterwards, the Defence Committee of the Cabinet

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was remodelled to include both the Political and Professional Heads of the Navy and Army. The labours of the Committee led to the establishment, in 1904, of the Committee of Imperial Defence and the creation of a General Staff; and in 1906-8 came the reorganization of the Army and Territorial Force by Mr. Haldane. Simultaneously military reforms were initiated in India by Lord Kitchener.

The first "Imperial Conference" met in 1907. To it, the Government submitted a memorandum, prepared by the new General Staff, on the reorganization of the Colonial Defence Forces on the lines of the reorganization of the British Army. Politically the most important resolution passed was the establishment of the Dominions on a status as "national entities distinct from the British Isles." It was recognised that "the basis of Imperial organization was the co-operation of five nations, not the centralization of power in the hands of the British, acting as the Imperial Government," and it destroyed once and for all the older conception of Imperial development, "as a gradual reunion of the Colonies with the Mother Country through representation in either of the British Houses of Parliament."

Colonel Fuller then gives an interesting *resumé* of events from 1907 to the outbreak of war in 1914, and concludes with a chapter on "The Value of Past History," in which he compares the aftermath of the Great War with the corresponding period after 1815. He says:—"After Waterloo the balance of power vanished. We retired behind our sea wall, our unattackable frontier, and the most formidable land power—Russia—with probably the best intentions in the world, tried to guarantee perpetual peace on earth by the establishment of the Holy Alliance.

"After the Armistice of 1918, the balance of power again vanished. Unfortunately, so I think, we did not retire behind our sea wall, but became entangled in the new Holy Alliance, the League of Nations. The establishment of this league was the idea of the strongest land power, the United States, but eventually, when level-headed people in America saw clearly where it would lead, they cast off their moorings and sailed in the opposite direction.

"Financially we are the leading power in the Old World, but the very terms we have bound ourselves at Geneva to support are diametrically opposed to the principles wherein our Empire has been born and nurtured.

"Self determination is the antithesis of the policy of domestic peace; not only has it been used to split Europe up into nations without economic resources or military frontiers, but it has had a disruptive effect in Ireland, Egypt and India. Self-determination of people who cannot guarantee their own domestic peace is synonymous with anarchy.

"Self-determination has already done us more harm even than the Germans did during the whole period of the Great War, yet, ironical as it may seem, self-determination of nations who can determine their own security has been a governing principle of British rule.

"Not content with abandoning principles (1) and (5) (as tabulated at the commencement of this review), we have, by agreeing to a one-power naval standard at the Washington Disarmament Conference, abrogated principle (4), and by doing so, not only have we undermined principle (3), but we have rendered it next to impossible to carry out principle (2).

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"If this old established policy is to be scrapped, what policy is to replace it ?."

Col. Fuller's answer to us is to get behind our sea wall, establish a League of British Nations, and let the League of Nations die the death, the sooner the better, of the Holy Alliance. H.B.-W.

A GREATER THAN NAPOLEON, SCIPIO AFRICANUS.

By CAPTAIN B. H. LIDDELL HART. (Blackwood. Price 12*s.* 6*d.*)

Comparisons are odious, but we doubt if there are many soldiers who have not debated at some time or another the relative merits of the great captains, with a view to a decision as to who was the greatest soldier in history. Following the lead of Napoleon, place may be given to Alexander, Hannibal, Cæsar, Gustavus Adolphus, Turenne, and national pride will have added Marlborough and perhaps Wellington, but few will have considered the claims of Scipio Africanus. It is with great interest, therefore, that we open this latest book of Captain Liddell Hart, and we are not disappointed. A strong case for a place among the military immortals has undoubtedly been made. Also the author has presented a live portrait of his hero, and on the whole a convincing one, whatever our views may ultimately be of his place in comparison with others.

Evidence has been drawn from probably all of the limited sources available. Unfortunately, all of these are written from the Roman point of view, and are, on the whole, favourable to Scipio. When the author claims Polybius as his chief authority, and a comparison with this historian's work shows that his text has been closely followed throughout, the reader may be excused if he tends to become hyper-critical. Polybius was a personal friend of Scipio's boon companion and faithful lieutenant Laelius, and admits that much of his information was derived from that source.

Armed with this knowledge, however, the most ardent critic cannot but admit the greatness of the unbeaten Roman general. The author attributes partly to this invincibility his hero's lack of lasting renown, and formulates the paradox that " the road to failure is the road to fame." The thesis is an interesting one and would repay a more extended study.

Captain Liddell Hart examines his subject from the widest point of view : as a man, a strategist, a tactician, and a statesman. Generous to his opponent, faithful to his subordinates, and wise in his support of constitutional power in the abstract, Scipio became the hero of his army, cemented the allegiance of allies, and strengthened his own position when resistance to political machinery seemed advisable. As a strategist Scipio will rank high, but the author's claim for a unique position for Scipio as an originator of new ideas seems rather overdone when the campaigns of other generals of his era are examined. In the realm of " logistical " strategy Scipio certainly stands out as a judge of the character and probable actions of enemy leaders, rulers and people. The tactical studies of the various battles are well done. A study of Zama makes one wish there were further evidence available to explain Hannibal's extraordinary inertia while Scipio re-organised his army, and reformed it into line formation. Was the Carthaginian army more

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disorganised than Polybius would seem to imply, or was Hannibal smitten with one of those inexplicable fits of inertia such as possessed the great leader, with whom his opponent is in this book compared, on 17th June, 1815?

We are, however, not completely convinced by the author's replies to certain criticisms which have been levelled against Scipio as a general. There is no doubt that he failed to achieve the objective given to him by the Government in Rome. This was to contain the Carthaginian armies in Spain, and prevent their junction with Hannibal in Italy. Excuses, and good ones, are given; but the fact remains that, if Scipio was never beaten in battle, he failed to carry out the role assigned to him. The reconnaissance in force sent to Africa under Laelius seems to bear some resemblance to the premature naval attack on the Dardanelles in 1915, though the latter had the merit of possessing a decisive objective.

As a statesman, conditions never placed Scipio in the position of an Alexander or a Napoleon, and so comparison is difficult. His foresight and breadth of view in dealing with allies and conquered peoples show him as centuries ahead of his time; indeed, the framers of the Treaties of Versailles and the Trianon might well have studied his principles.

Captain Liddell Hart makes frequent and valuable comparisons between the actions of Scipio with similar events of the last two centuries. The training camp at Syracuse is linked with that of Shorncliffe, and the entrenched camp near Utica naturally recalls its modern counterpart in the lines of Torres Vedras.

It is a pity that in lauding his hero the author has tended to slight the memory of other contemporary leaders. Quintus Fabius appears as the superannuated soldier-politician of clubland rather than the general who had led Roman armies to victory, and did more than most other generals to check Hannibal on what might be called "the western front in Italy," while Scipio gained his victories over other Carthaginian armies on the apparent "side show" in Spain.

Whatever we may think of Captain Liddell Hart's plea for pre-eminence for Scipio, we are grateful to him for having done honour to a great soldier and gentleman in a book which is at once delightful reading and a valuable biography. R.P.P-W.

LA GUERRE TURQUE DANS LA GUERRE MONDIALE.

By COMMANDANT M. LARCHER. Preface by Marshal Franchet d'Espérey. (Paris: Chiron. 57 fr. 60).

Commandant Larcher is a staff officer and Turkish scholar, who had already translated into French the Turkish official account of the Dardanelles campaign. Here he has undertaken an enormous task: to describe all the military operations in which Turkish troops took part between 1914 and 1918, to estimate the importance of Turkey's efforts in the Great War, and those of the other belligerents who were her allies or her opponents, particularly Britain, France, and Germany. His work has considerable value, since it is largely based upon Turkish accounts, which few European soldiers can read, and also because he has taken it very seriously. His bibliography covers 15 pages, with

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about 25 volumes or periodicals to a page, though, curiously enough, he has missed the most important contribution to the Palestine Campaign yet published, the seventh volume of the Australian official history—perhaps because this was published in Sydney. He gives us 65 sketch-maps, and what is still more useful, a large number of tables, orders of battle, etc.

On the whole he cannot be said to be particularly friendly to Great Britain. He exclaims at the contrast between British and Turkish strengths in Palestine—rather exaggerating the disparity in numbers—without explaining how largely that campaign was an engineers' war, and how, time and time again, only the lack of water and the extraordinary difficulties of supply prevented the destruction of the Turkish forces. He writes:

> "The operations from the 31st October to the 9th December, 1917, had cost the Turks 12,000 prisoners and 100 guns, mostly abandoned for want of teams. These were light enough material losses. The Turks had twice escaped the encirclement carefully prepared by an army incomparably superior."

Granted, but he might have added a rather fuller account of the causes, which were not entirely British lethargy, as he seems to suppose. He might also have added that the casualties of the enemy between the 31st October and 31st December of that year, according to the admission of the Turkish Historical Section, were: Officers 1,039, Other Ranks 27,034, Animals 5,270. These cannot be called "light material losses," as they represent very nearly the Turkish rifle strength on the earlier date. His book is nevertheless well worth study as a remarkable general picture of Turkey at war. Many hints also can be gained from it as to the causes of the country's military and moral renaissance after a series of great disasters. C.F.

TASCHENBUCH DER TANKS.

(Price 12 marks).

The firm of J. F. Lehmann, of Munich, which has published its 23rd annual pocket-book of War Navies and its 5th annual pocket-book of Air Fleets, has broken fresh ground with a pocket-book of the Tanks of all nations. It was a happy idea thus to bring "Land-fleets" within their province, since it has collected in a small and really portable form a vast amount of information important to officers in general and to staff officers in particular. To all ranks of the Royal Tank Corps the book should prove a fascinating study and a mine of knowledge and ideas. The author, Capt. Heigl, late of the Austrian army, dedicates his book in the first instance to the German and Austrian armies, since they, being forbidden at present the possession of tanks, must specially study a weapon to be reckoned with in future wars—a weapon, moreover, so powerful that in conjunction with the aeroplane it may well be decisive. He thereupon divides his book into three parts. The first part is technical and deals in 50 pages and 5 plates with the principles of the construction of the most important types of tank, paying special attention to those things which distinguish the tank from other motor vehicles, e.g., chain-drive, steering, armouring. The 2nd part is devoted to tank identification

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under the headings of the various nations, each important type getting a photograph and a plate of 5 figures, showing side and front silhouettes, side, front and rear elevations, and also two small-scale bird's-eye views, differently illuminated, *i.e.*, throwing shadows of widely differing shapes. Under the nations, we find that Great Britain leads with 57 pages. It is not known what secrets, if any, are here disclosed, but the War Office will no doubt have taken cognisance thereof. France follows with 36 pages and the U.S.A. with 32. Russia 21, Poland 13, Latvia 11½, Italy 10, come next. Belgium, Roumania, Spain, Czecho-Slovakia, Lithuania, Finland and Japan receive quantities varying from 9 to 3½ pages, while Brazil, Chili, Germany, Esthonia, Greece, Jugo-Slavia, Persia, Sweden, and Switzerland also receive mention. There follows a chapter on the identification of tanks in aeroplane-photographs. Part 3 is devoted to the methods of employment of tanks, as exemplified by British and French formations and attacks in the past, in order to work out the best means of defeating tanks in future. It deals first with active defence and then shows what a tank can do and cannot do, in order to arrive at the best means of passive defence. This part with its numerous plates and photographs is carefully worked out and rich in examples and instances.

In short the whole work reflects great credit on author and publisher. No English would-be reader need be deterred from ordering the book through a deficient knowledge of the language, since the publishers have wisely chosen Roman type instead of German, and the numerous plates and photographs speak for themselves. F.A.I.

CRITICAL STUDY OF THE CAMPAIGN IN MESOPOTAMIA UP TO APRIL, 1917.

Part I—Report. Part II—Maps.

For official use only. Published by the GENERAL STAFF, A.H.Q. India (1925).

THIS study comprises the results of a visit of students of the Staff College, Quetta, to Mesopotamia, in 1923, together with a reprint of the accounts of the actions at Sheikh Saad, Wadi and Hanna, by Major-General Sir W. D. Bird, previously published in the *Journal of the U.S.I. of India*, and notes on the L. of C. by Lieut.-Gen. Sir G. F. MacMunn.

Representing as it does for the most part the results of detailed investigation on the spot, the publication is of great value to any student of the campaign. It is, however, only obtainable from official sources, and as the number of copies available is limited, its usefulnes is, unfortunately, likely to be restricted. C.A.B.

A BRIEF OUTLINE OF THE CAMPAIGN IN MESOPOTAMIA, 1914-1918.

By MAJOR (Temp. LT.-COL.) R. EVANS, M.C., *p.s.c.*, Royal Horse Guards. (Sifton Praed & Co., Ltd. 7*s.* 6*d.*)

IF full value is to be obtained for the time spent on the detailed study of any campaign, a sound grasp is necessary of the general outline of policy and strategy underlying it. The publication of this outline of the campaign in Mesopotamia is, therefore, most opportune.

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Criticism and consideration of alternative plans are restricted to a minimum, presumably in order to limit the size of the book and to encourage the student to work these out for himself.

The addition of a few test questions to assist such study would enhance the value of the book to candidates for promotion and Staff College examinations.

The full Table of Contents obviates the need for an index, but the use of marginal or paragraph headings would facilitate reference in the letterpress. C.A.B.

NOTES ON THE CAMPAIGN IN FRANCE, 1914.

By LIEUT.-COLONEL A. KEARSEY. D.S.O., O.B.E., *p.s.c.* (Sifton Praed.) Price 3/-.

THIS is a small book intended for use in preparation for promotion examinations. The first two chapters present appreciations from the German and Allied points of view at the outbreak of war. These are not complete, as they assume concentration dispositions which in turn depended on the general plans. The German plan given, however, is rather Schlieffen's original plan than that actually adopted by Von Moltke. Other chapters contain an outline chronology of the period up to 23rd September, with lessons to be learnt from the principal engagements. Appendices are added to enable students to draw diagrammatic sketches to illustrate the major movements. Finally the student is left with 29 questions to consider. A useful skeleton map printed in grey is attached. The book will give the student points for consideration in the study of the period. R.P.P-W.

THE CHINESE ARMY AS A MILITARY FORCE.

By LAWRENCE IMPEY. (Tientsin Press, Ltd., 1925). Price 12/6.

The author of this short account of the fighting which took place in Northern China during 1924 and 1925 has attempted to estimate, by European standards, the military value of the forces employed by the three principal Northern "War Lords."

In this he has chosen a difficult task, because European standards are so often inapplicable in China. Factors which, in other parts of the world, would be decisive, are either inapplicable or of little importance to the Chinese "wars." These are usually decided by conditions and actions of which the European can have little knowledge, and would not consider as important if he had.

Mr. Impey acted as "War Correspondent" during the short campaigns which he describes, and his remarks and photographs are interesting. His conclusions, however, appear to be, sometimes, rather contradictory. This may be accounted for by the effect of that curiously widespread and infectious "Yellow Peril" obsession, which at times seems to get the better of him. When, however, the logic of what he has really seen for himself is allowed to influence him, his conclusions are much more reasonable. He then admits, what all who have studied the question will agree with, namely, that there is no possibility of China waging a war with any foreign power with any measure of success for at least 50 years.

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A few facts extracted from his book will show that he has not made an under-statement.

Wu-Pei-Fu, reputed one of the best generals in China, allowed his principal lieutenant, of whose loyalty he was doubtful, or, rather, of whose disloyalty he was convinced, to remain, with his best troops, in command of a vital position. The lieutenant duly betrayed and ruined his master. The same story could be repeated a hundred times; in fact, it is not too much to say that no campaign has, in recent years, been decided by anything except treachery. Fighting has had little to do with it.

Although the Chinese soldier is capable of some personal loyalty to a leader, the latter feels no corresponding impulse towards his men. Wu-pei-fu, when defeated near Tientsin in 1924, left his troops in the lurch and fled by sea, with the few more or less serviceable cruisers still existing in the Chinese Navy, to the Yangtze, picking up a little money en route at Che-Foo by threatening to bombard the port unless it was forthcoming, It was one of his own ports too.

The troops of Wu-pei-fu varied very much, in quality, amongst themselves. If compared with those from more distant parts of China, even greater differences would be observed. But even the crack 3rd Division, probably the best in China, is put at only one-third as good as a European Division. For most divisions the writer records complete absence of officers whenever fighting or a job of work was in sight; cowardice; lack of tactical enterprise or skill; lack of discipline, loyalty, or fighting spirit. Even of the 3rd Division he says that very few officers stayed with their men when things began to look bad.

Of the Chinese horsemen little was seen, and that was chiefly mounted infantry. The Chinese can ride very well, at any rate in the North, and both they and their mounts are wonderfully hardy, but as fighters they do not amount to anything more than their brethren in the Infantry. In the far west, in Mongolia and Turkestan, good looking mounted soldiers have been reported, but they are probably bandits fighting for their living, not armies fighting for someone else's cause.

The Artillery on both sides is reported as having "displayed a most lamentable ignorance of the first principles of gunnery." "Forward observation was practically non-existent; discipline extremely lax"; no telephones, etc., etc.

It should be noted that as there are no roads in China, field artillery is the heaviest that can be moved. Very often a kind of pack trench mortar has to take its place. Ammunition is naturally not plentiful, so that the heavy artillery bombardments, of which the newspapers sometimes speak, are not so serious as they sound.

For the Air Forces on either side, the writer can find no good word to say. They brought no information and took no photographs. They did not fight each other, perhaps because they were unarmed except for pistols, and produced practically no results by bombing, in spite of very favourable targets. As for the Anti-Aircraft guns, there was only one, of apparently about 1½" calibre, and that soon ran out of ammunition.

Of the transport, administrative and medical services "lamentable failure" is recorded. Any officer or soldier would dictate how trains

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should run, and brutally illtreat the railway staff if the latter demurred. Hundreds of trucks were used as dwellings, and while there was a block of some 200 trains on one line, that running beside it was empty. The writer does not mention what he might also have seen, that is, trucks crammed with ponies of which many had died of starvation or thirst, but what he did see was enough to justify him in terming the transportation service "absolutely incompetent."

One of the Army commanders did, in 1924, make a crude attempt to supply his men with rations. It was thought to be, and was, a wonderful innovation. Though the Chinese soldier can probably exist where any other would starve, yet even he objects to having to rely on roots pillaged wherever they could be found, and eaten raw for lack of fuel.

Wu-pei-fu's men had only their thin cotton summer uniforms, though a winter of arctic severity was rapidly approaching. Chang's men were better off in that respect, and also had boots in place of the miserable felt-soled cloth shoes of their opponents.

The Medical Service was what one would expect from a people described as "entirely indifferent to it from a humanitarian point of view," and considering it "practically useless as a military adjunct." Dressing stations, where they existed, were in charge of corporals equipped only with buckets of water and a few bandages. Medical officers and stretchers were equally scarce, and numbers of wounded died of exposure while waiting for or travelling in the cattle trucks composing the "hospital train." Few if any wounded men ever return to their units, at any rate until the next campaign, and then, probably, on the opposite side.

The contrast between the utter worthlessness of the Chinese Armies and the many valuable military virtues of the individual soldier is most puzzling. The latter is, at any rate if he is a Northerner, docile, cheerful and indifferent to hardships which would kill a European. He is sturdy, intelligent, and not without a good share of courage, though this is of a special kind. He will not go to meet danger, but he does not much mind danger coming to meet him. This makes him far less formidable in attack than in defence. But he is not really very formidable in either, and no one seems able to make much of a soldier out of him. The most successful attempt was probably that of the British with the Wei-hai-wei Regiment; but its men were the pick of Shantung, from which province come the best fighting men in China.

The Southern Chinese Armies possess all the weaknesses of the Northern and many others as well. In them the individual soldier is often of wretched physique, and soaked with malaria and opium. Though possibly of a quicker intelligence than the Northerner, he is less amenable to discipline and more appreciative of danger.

Both the Northern and the Southern Armies are quick to acquire the outward forms and mannerisms of foreign troops, for no one can copy so well as a Chinese, but of the meaning and purpose of these forms they have little idea. The "Christian General" has battalions whose close order drill compares favourably with that of the best foreign troops, but they appear to think that nothing more is required.

They are also quick to acquire the very latest technical equipment, but this, if not already fit for the scrap-heap when sold by the gun-runner

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soon becomes so after a few months of Chinese neglect. Even when it is serviceable they have no idea of how to use it, and appear to think that its mere possession is sufficient. Yet they are by no means devoid of technical skill, and can make things work in a sort of way long after anyone else would have condemned them as worthless. Since life is so cheap, and material so valuable, factors of safety need not be considered, and if an aeroplane or an armoured car can be patched up with string and sticking plaster, it is made to go.

It is, however, the never-failing treachery in the leaders of these armies which, more than anything else, makes them so worthless. Since every general is at war for the sole purpose of gaining a position in which he will be able quickly to make money from his unfortunate countrymen, it follows that his price is fairly well known, and the question of when and by whom he will be bought is openly discussed.

It may be said that this would not apply if the Chinese Armies were engaged with foreign troops, but even in the past, when China was more or less united, they could effect very little against the foreigner. They could not even capture the Foreign Legations at Peking in 1900, though these were most unfavourably situated for defence, and garrisoned by little more than a handful of mixed foreign troops hastily collected from any available source. Similarly, against the Japanese in 1894, their efforts were puerile. In both these cases infirmity of purpose, divided counsels, and lack of control, were the principal causes of failure. Now that China is every year disintegrating into smaller fragments, a conflict between the leader of any one of these and a foreign power would probably be regarded as a Heaven-sent opportunity by his rivals.

The "Yellow Peril" idea has been attributed to Wilhelm II. He seems to have been as mistaken there as he was on another subject.

L.C.-T.

THE ENGINEER AND THE PREVENTION OF MALARIA.

By HENRY HOME, M.INST.C.E. (Chapman & Hall, Ltd.) Price 13/6.

In undertaking any anti-malarial measures, the engineer is confronted with the problem of how to obtain the best results with the least expenditure of money. There are many reference works on drainage of swamps and marshes and on river training, and also many publications on public health, entomology and parasitology, but very seldom can one find specific references to anti-malarial schemes.

The volume under review is an attempt to show how co-ordination between the engineer and the medical authorities is necessary in order to carry out efficient and economical anti-malarial measures.

Until the actual species of *Anopheles* which is dangerous to the district concerned is identified, and its actual or potential breeding places discovered, it is a waste of time and money to carry out an attack on mosquitoes in general. This point is clearly brought out in the book, and Chapters I to III give a short description of the habits of the more common malaria carriers and the general principles on which anti-malarial schemes should be carried out.

It is a pity that Chapter III is so short, and more examples of successful anti-malarial measures might well have been given.

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Chapters IV to VIII are an engineering treatise on drainage, with occasional reference to points which arise in connection with *Anopheles* breeding places. This subject is so large that it is of necessity very much condensed and the author cannot do more than give a brief description of various methods of drainage.

In some instances he goes into details and recommends specific appliances which may or may not be useful in any particular scheme. These chapters would have been more useful if the author had confined himself to broad principles.

The remaining three chapters dealing with anti-malarial services and preventive measures, are useful. D.K.E.

GUN RUNNING IN THE GULF AND OTHER ADVENTURES.

By BRIGADIER-GENERAL H. H. AUSTIN, C.B., C.M.G., D.S.O. (John Murray). Price 7/6.

General Austin has had an adventurous career and he also has the art of telling a good story well. These tales of his experiences when on secret service in the Persian Gulf and in various responsible posts in Iraq, Africa and the North-West Frontier of India, will be read with interest as showing some of the extraordinary problems that may confront an officer of the Corps. A sketch map, after the manner of John Buchan, would have been a useful addition to the account of the gun-running adventures.

WARRIORS AT EASE.

By A.A. (ANTHONY ARMSTRONG). (Methuen and Co.) Price 3s. 6d. tales, collected from *Punch*, illustrating the peace time life of "that astonishing infantry."

FRENCH MILITARY ORGANISATION AND MODERN FRENCH-ENGLISH MILITARY TERMS.

By J. PSOMADES (Librairie Hachette). Price 4s.
An attractive little book, but M. Psomades' pupils could have corrected many of the *English* military terms. F.E.G.S.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

April, 1926.—The fifth number of Lieutenant-Colonel Grasset's *Verdun—Le Premier choc à la 72e Division* describes the evacuation of Brabant on the left of the line and the counter-orders of the higher command on the decision of the divisional commander to evacuate this village, which had become untenable. The Corps and Army Commanders appeared obsessed with G.Q.G.'s order to give up no ground, and in consequence the recapture of Brabant was ordered, after hours of hesitation on the part of the Corps Commander, who, however, instructed General Bapst, commanding the 72nd Division, not to use up too many

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troops! The author evidently considers that General Bapst, who was the man on the spot, was perfectly justified in his decision.

In *Réflexions Suggérés par 6 Mois de Campagne au Maroc en* 1925, Général Dosse gives an interesting résumé of the characteristics of the Rifis and the lessons learnt from the campaign. The resemblance of the tactics of the Rifis to those of the Afghans and the tribes of the North-West Frontier is striking; the article brings out most of the principles of mountain warfare as laid down in our regulations.

La Prise de Contact et l'Engagement, by Commander Nalot, is completed in this number. The writer again expands various regulations on the subject, drawing particular attention to the distinction between an advanced guard action intended to pin down the enemy and obtain information, and a divisional attack intended to break through the enemy's dispositions.

The second instalment of *Les débarquements Alliés aux Dardanelles*, by Commandant Desmazes, deals with the attacks of May and June on the Helles front, and the appearance of a condition of stalemate and consequent trench warfare. During this period General Gourand took over command of the French troops from General d'Amade, and suggested a fresh landing about Gaba Tepe, with the object of outflanking the Achi Baba position and gaining Maidos. The culmination of this idea in the Suvla operations is described in the next instalment.

Général Camon, in his *La Division Légère Automobile, Son Organisation*, bases his suggested "Light Division" on Napoleon's organisation of a cavalry division. The proposed organisation consists of three groups: The first, for reconnaissance, consisting mainly of motor cyclists with a proportion of automatic and anti-tank weapons; the second, forming the main body and composed of infantry in lorries and mechanicalised artillery; the third group being similar to the second and available as a reserve. It will be noticed that tanks are omitted and the horse eliminated.

Chef d'escadron Paul Block begins an article entitled *La Guerre Chimique* in this number. The first instalment is devoted to a detailed description of the various forms of gas which may be employed offensively in war. A considerable part of the article is devoted to technical descriptions of the types of projectile employed and the component parts of the different gases.

May, 1926.—Lieutenant-Colonel Grasset describes the resumption of the German onslaught on February 23rd in the sixth instalment of *Verdun—Le Premier Choc à la 72e Division*. It was a day of soldiers' battles, in which nearly all commanders were continually out of touch with the situation. The Commander of the 30th Corps ordered a series of counter-attacks, each by not more than a battalion; but all of these, doomed to failure from the outset, had to be given up before the German advance. The close of the day finds the division about to be relieved, after a magnificent resistance, owing to which the second line of defence is still generally intact.

The third instalment of *Les débarquements Alliés aux Dardanelles*, by Commandant Desmazes, describes the Suvla Bay operations in some detail. The operations are clearly outlined, and the section on the

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Turkish dispositions, drawn from the Turkish history and Liman von Sanders' book, emphasises the lost opportunities of August 7th and 8th, when the objectives allotted to our 9th Corps were to be had for the asking. Finally, the vigorous action of Mustapha Kemal was mainly instrumental in holding up the British attack when it materialised.

Commandant Schneider's *Etude sur l'Artillerie Légère Puissante* describes the value of the mortar as a trench warfare weapon, and at the same time forecasts the use of the same weapon in mobile warfare. The writer deplores the fact that the mortar is now in a state of suspended animation (as in the British Army) and considers that, even in mobile warfare, mortars on light carriages will be essential for close support of the infantry. He considers, however, that the mortar is essentially an artillery, not an infantry, weapon.

La Question de la Limitation des Armements Devant la Société des Nations, by Commandant "S," is a somewhat academic discussion of the various phases of the disarmament problem, culminating in the Commission, appointed by the League in December, 1925, to prepare for a conference on the limitation and reduction of armaments. The chief interest of the article lies in the continual divergence of the French and British points of view, which crops up at nearly every turn.

The second number of Chef d'escadron Paul Block's article, *La Guerre Chimique*, is far less technical than the first. The writer, while affirming that gas will never be used by France unless she is forced to do so in self-defence, evidently considers that chemical warfare has come to stay. The tactics best suited to the employment of gas are described, and the instalment concludes with a discussion of the prospects of an unscrupulous nation springing a technical surprise on its adversary, a surprise which might have decisive results.

June, 1926.—Lieutenant-Colonel Grasset completes his most interesting and instructive article, *Verdun—Le Premier Choc à la 72e Division*, in this number. Two outstanding features of the operations of February 24th were the shelling by French guns of the remnants of the heroic garrison of Samogueux under Lieutenant-Colonel Bernard, of the 351st Regiment, and the brilliant counter-attack of the 35th Regiment of the 37th Division on Hill 344, thereby preventing the Germans from breaking right through the second line of defence. This operation illustrates the effect of an *immediate* counter-attack, compared with the futility of previous counter-attacks carried out by units after the enemy had had time to consolidate his gains. When finally relieved by the 37th Division, the 72nd had practically ceased to exist, but it had earned undying honour by preventing a break through by immensely superior numbers at the first onset.

The fourth instalment of Commandant Desmazes' *Les débarquements Alliés aux Dardanelles* is particularly interesting in its description of the various plans suggested by the French and British authorities between Suvla and the final evacuation. General Sarrail had been placed in command of the French forces, and operations on a large scale on the Asiatic shore had been practically decided on, when Bulgaria's entry into the War upset all previous calculations. The various points of view are well and clearly put with a refreshing absence of criticism.

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In completing his *Etude sur l'Artillerie Légère Puissante*, Commandant Schneider points out that, as long as infantry are required in battle, a close support weapon will be essential. The various requisites for this weapon are fully discussed, and the writer comes to the conclusion that no modification of the existing 150 mm. mortar (originally a trench warfare weapon) will be satisfactory, and that a new type of mortar should be designed. His conclusions are of interest in view of the obvious limitations of pack artillery, as employed in our army, for close support of the infantry.

Communications et Ravitaillements au Maroc, by Capitaine Juin, clearly illustrates the administration difficulties of operations in undeveloped countries, especially against an active and well-armed enemy. The writer describes in some detail the measures which had to be taken by the "4e Bureau" ("Q" staff) in order to put the plans of the "3e Bureau" ("G" staff) into effect. A point of interest is the employment of a private firm, "l'entreprise Mazères," for providing a large proportion of the mechanical transport required.

In the third instalment of *La Guerre Chimique*, Chef d'escadron Paul Block discusses the various methods of collective and individual protection against gas. The number concludes with an estimate of the effect of gas on horses, which the writer considers to be far less affected by gas than by actual shell fire, and a short discussion on smoke shell and generators.

The greater part of the first instalment of *L'Armie Anglaise et ses Grandes Manœuvres de* 1925, by Commandant "T," is devoted to a description of the present organisation of the British Army. The writer points out how our present training is aimed at a war of movement, and comments on what he calls the "young school," which considers that the War Office is moving too slowly towards general mechanicalisation. The writer concludes with the statement that the "doctrinal ideas of our phlegmatic allies were, therefore, in the melting pot at the outset of the manœuvres."

H.A.J.P.

REVUE DU GENIE MILITAIRE.

(*July*, 1926).—*Exploitation of firewood in the Forest of Dreux during the War.* A short description of the supplementary organisation and output of this service in a forest already under exploitation by Canadian troops for constructional timber.

Construction of a piled bridge over the Moselle at Pont-à-Mousson by the 9th Regiment of Engineers. Details of the bridge, organisation, and methods of construction with comments—illustrated. The writer finds that recruit personnel rapidly adapted themselves to the use of the compressed air pile-driver—70 H.P. Ingersoll 2-cylinder compressor and two monkeys, 3,000 lbs. and 1,500 lbs., of which the latter was generally sufficient for the piles used, which were round, and 10 to 12 inches diameter, and some 40 ft. long. While the manual of instruction states that such piles can be driven in 45 minutes, it was found that two hours was the average time involved. Some of the pile driving was done with service equipment and the writer notes the

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speed gained and the personnel saved by the use of a power plant as compared to a hand winch.

The construction of a cast-iron bridge in 1863 *at El Kantara, and its replacement by a ferro-concrete bridge in* 1924-25. A description of both bridges and details of the method of reconstruction (illustrated).

(*August*, 1926).—*Defence of Frontiers.* An extract from a paper prepared in 1818 for the Commission of Defence instituted in that year. The author discusses the advantages and disadvantages of defended localities prepared in peace time, and having satisfied himself that they are required under certain conditions lays down the points to be borne in mind, in locating and equipping such places.

Destruction and repairs of roads, railways and bridges and devastation of areas. A short historical summary of practice in the past with a more detailed account of the work done in the war of 1870-71; and in Belgium and France up to the Battle of the Marne. (*To be continued*).

Demolition of a Brick Chimney. The chimney was 40 metres high, the brickwork at the base 1 metre thick. The problem was to demolish it without injuring the neighbouring buildings. The chimney was damaged by a previous fire. The charges were placed with the object of throwing the chimney in an innocuous direction. Actually, on firing the charge, the chimney collapsed on its base.

An anticipation of the Tank. Reprint of a document written in 1774, describing and illustrating a wooden shield carried on a two-wheeled handcart. The shield is pierced with loopholes and when tilted up enables 12 muskets to be fired through the loopholes. H.G.K.W.

BULLETIN BELGE.

(1926. *Tome* I. *Nos.* 4 *to* 6 *inclusive.*)—*Operations of the Belgian Army*, 1914-1818. A scheme had been drawn up in 1913 for strengthening the defences of the "retrenched camp" of Antwerp on the left bank of the Scheldt, but, when the war broke out in the following year, no progress had been made with the provision of the additional permanent works projected; in consequence, the construction of the field works was at once begun in the early days of August, 1914, with a view to improving the defences of this "retrenched camp." A short description of the work carried out is given in No. 4: the troops told off for the defence of the 5th Sector of the Belgian Citadel, and the situation as it existed at October 8th, 1914, in the 6th Sector, are also dealt with in the same number.

An account of the operations of the Belgian Army on October 9th is given in Nos. 5 and 6. The Belgian 3rd, 4th and 6th Divisions, which had been covering the stretch of railway between Ghent and St. Nicholas, were able to slip away, without the enemy's knowledge, during the night of October 8th-9th, and on the latter date lay westward of the Ghent-Terneuzen Canal in the billets assigned to them, where they rested for the day—the bridges over the Canal at Selzaete, Terdonck and Langebrugge were still guarded and were prepared for demolition. Von Werder, who was in command of the Left Wing of the besieging force, had been ordered to push on to the Durme as quickly as possible and to seize Lokeren, but he had advanced with great caution, contenting

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himself with a violent artillery duel, and his leading troops had, in consequence, at this time only reached Boxelaere and Everslaer. A report, which proved to be false, had led the Belgians to believe that the Germans had reached the neighbourhood of Moerbeke and St. Nicholas; the line of retreat of the R.N.D. and the Belgian 2nd Division seemed, in consequence, to be seriously threatened. The Belgian High Command, therefore, took steps to warn the formations in question of their danger, and, at the same time, caused measures to be adopted with a view to safeguarding the railway during the passage of the trains which were to convey the R.N.D. from Antwerp to the coast.

The hesitation of von Werder's troops to push rapidly on to the Dutch frontier enabled the R.N.D., the Belgian 2nd Division and certain fortress units to reach Selzaete in safety. The arrangements made for the protection of the Line of Communications from Antwerp are described in No. 5. Ghent was at this time held by a mixed force of British, French and Belgian troops totalling about 20,000 men. Reinforcements sent by the German Governor-General of Belgium to von Werder were directed on October 9th to advance on Ghent; in doing so they came at Quatrecht into contact with a small detachment of French troops, which fell back before superior numbers to Melle, where, after some skirmishing, the further advance of the Germans was temporarily checked. A brief review of the strategical situation at this time is contained in No. 5.

The events of October 9th in the Pays de Waes, and the arrangements in connection with the transport of the Belgian Field Army to the line of the Yser are dealt with in No. 6. At this time grossly exaggerated reports of the progress made by the Germans in the neighbourhood of Ypres reached Belgian Headquarters, and caused some disquietude, as it had been intended to utilise the railway line from Ghent, *via* Deynze and Thielt, to Dixmude, for the transport westward of the troops at Ghent. In view of the reports above-mentioned, the Railway Administration eventually decided to utilise the double track from Ghent to Bruges for the transport of the Belgian 3rd, 4th and 6th Divisions.

The Frontier Battle. The operations of the Allied Left Wing during the period August 21st-23rd, 1914, are dealt with in No. 4; the article is a continuation of a contribution by Major van Overstraten, on the opening phases of the Great War—the first of the series is published in No. 1 of the *Bulletin* for 1926. An account is given of the fighting on the Sambre and Meuse, at Charleroi, Namur and Mons, and in connection with the first Belgian sortie from Antwerp; the handling of the German Right Wing during these operations is briefly examined and the results summarised.

Battle of Liège (1914). Captain-Commandant Paquot gives an account in No. 4 of the German advance on Liège at the outbreak of the Great War. He deduces the principal reasons for the failure of the Belgians to hold the Germans at bay at this fortified centre for a longer period than was actually the case, and summarises the lessons to be learnt from the operations in question.

The Proper Relations between Governments and High Commands. In the case of a war in which the whole of the resources of the belligerent

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nations must be brought into play in aid of the military effort, it is essential that the exact spheres of responsibility severally of Governments, Legislatures and the Supreme Military Commanders should be clearly understood by them, in order that in each case those on whom the responsibility rests may adopt measures for the effective and efficient performance of the duties, within their own respective spheres, in such a manner as to avoid improper interference with the recognised task of the one by the other or others, and thus jointly promote the success of the combatants in the field in the highest degree. Unfortunately, history tells of many instances in which improper interference in the sphere of responsibility of a military commander in the conduct of operations has been attempted by the politician—sometimes with disastrous results. It is well then that the subject should be amply discussed in times of peace; for this reason the article by Captain-Commandant Dendal, entitled *Des Rapports entre le Gouvernement et le Commandant*, which appears in No. 5, and in which the problem relating to the proper sphere of responsibility of a Government, the Legislature and a Supreme Military Commander, is ably dealt with, should be welcome alike to soldiers and politicians.

The Role of the Engineers. A lecture on the role of the Divisional Engineers in connection with the preparation of a defensive position was given in Brussels on January 9th, 1926, before the *Cercle d'instruction des officiers de réserve*, by Captain-Commandant Beaupain. A summary of this lecture is given in No. 6, under the title *Role du genie dans l'organisation, progressivement conduite, d'une position défensive;* it should prove of interest to the young Sapper Officer.

Le Chef Officier. In an interesting article under the foregoing title, published in No. 6, Captain Jacoby discusses the attributes of commanding officers of units as well as of formations. W.A.J.O'M.

MILITÄR WOCHENBLATT.

4th May, 1926. (1). *Technical Review.* An article dealing with recent technical developments of military interest, including a new self-calculating fire-control apparatus (U.S.A.), a Diesel-engine for Mechanical Road Transport (Germany), a "Stroboscope" for tanks (U.S.A. and France), pliable glass (Australia and Austria), and the preparations for an industrial mobilisation of the U.S.A.

(2). *Umpiring during Training.* The difficulties of the umpire's task are analysed and constructive suggestions put forward.

(3). *"Militär Wochenblatt" and "Army Quarterly."* A note on the review in the "Army Quarterly" for April, 1926, of General Wellmann's book "Das 1 Reserve Korps in der letzten Schlacht." The writer takes exception to a footnote in the review which asserted that the "Militär Wochenblatt" had invited subscriptions to "a new national daily paper . . . . . entitled 'Der Tag.'" No such paper is known to the "Militär Wochenblatt."

11th May. (1). *Development of the Italian Air Service.* The new Italian air estimates show an increase of 180 million lire over the last budget. In this connection past and future developments are discussed.

(2). *The heavy machine gun in the attack.* The writer describes the

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methods of employment of this arm in the attack and arrives at the conclusion that even more importance should be attached to its employment in the future than has been accorded to it in the past.

18th May. The Tank of the Present and of the Future. The first instalment of a detailed analysis of Tank developments in all armies. A short introduction is followed, by sections, on speed, mobility and armament. As regards mobility, great admiration is expressed of the performances of the British Medium Mark D Tank. High speeds are, in the writer's opinion, only obtainable with elastic tracks. Tanks should, in general, be heavily armed. The modern Tank in motion can produce effective M.G. fire up to 300 and artillery fire up to 1500 metres.

25th May. The Tank of the Present and of the Future. The article on this subject in the previous number is concluded. Modern tanks have a radius of action of as much as 1000 kilometres (625 miles). The tank of the future will probably be gas-proof. Present types of tank are shortly discussed and the value of the one-man tank is doubted. The effects of the employment of tanks on modern tactics are described and analysed. The article concludes with notes on inter-tank communication and anti-tank methods.

4th June. (1). *The Disarmament Conference at Geneva.* Progress is discussed. The writer concludes that the disarmament question will probably break down owing to its inherent difficulties. Neither England nor America are likely to use all their power to prevent this.

(2). *Entrainment of troops in retreat and the flight of the civil population.* The writer quotes war experiences, notably the retreat after Gumbinnen in 1914, to prove his thesis that railways should be kept absolutely clear for the transport of troops and war material in retreat and that civilians should be prevented from leaving their homes to the mercy of the advancing enemy.

11th June. Tradition Companies. The importance of traditions of the old army, as maintained by units of the present German army, is discussed in all its aspects.

18th June. The Red Army. A description of the present conditions of service in the Russian army. Russia will always be able on mobilisation to raise a trained force of greater strength than any combination which might take the field against her. Notes are appended on the militarisation of civilian higher educational establishments, the military budget, military attachés and the pensioning of officers.

25th June. (1). *France since Autumn, 1925.* A general survey of the foreign and inner-political situation in France. The favourable influence of Locarno and the surrender of Abd-el-Krim is discounted by the political situation in the Mediterranean and by France's position at the disarmament conference.

(2). *The Red Army.* Notes on Russian views on flame projectors, gas warfare and on the militarisation of the civil population.

4th July. (1). *Man and Material.* A dissertation on the psychological factor in modern warfare, with examples from the late war. The writer concludes that human courage will always keep pace with the development of technical weapons.

(2). *History of the German Eagle.* An interesting article on the national

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badge, which was first reported on the standard of Otto II (967-983).

11th July. The Legend of the superiority of the French Artillery in 1914. A review of the merits and demerits of the most important pieces of German and French ordnance. A tabular comparison proves to the author's satisfaction that neither artillery could be considered to be definitely superior to the other.

18th July. Horse, Motor and Bicycle. The author regrets that in the frequent discussions on motorisation the bicycle has been apparently forgotten, and points out, with examples, its immense value in war.

25th July. (1). *The Disarmament Conference.* A review of progress achieved hitherto, culminating in the expressed opinion that, with the exception of Germany and America, the states involved only wish to "save the Versailles system" and are using the conference as a means of justifying the "military and political injustice" inflicted on Germany at Versailles.

(2). *Aircraft for military transport purposes.* The author is of the opinion that aircraft will play an important part as transport vehicles in a future war. Figures of comparative performance of Mechanical Road Transport, Horsed Wheeled Transport, Pack Transport and Aircraft are produced to support his thesis.

4th August. (1). *Italy's position in the Mediterranean.* The writer emphasises the growing strength of Italy in the Mediterranean. The time is not far distant when England will find it difficult to maintain her present strong position in these waters.

(2). *The Polish Army.* A review of the situation in the army since Pilsudski's *coup d'état.* Almost all his opponents have disappeared from the most important posts. Relations between army and civilian population and between officers and men are said to be very bad.

11th August. Training Manuals of the German Army. A description of the new German manuals, which have been compiled in the course of the last few years on the basis of war experiences. The writer points out that several years of training on the new basis will be necessary before effective criticism of the manuals is possible.

18th August. (1). *Covering fire by heavy machine guns in attack over flat country.* The writer recommends that Heavy Machine Guns should not be controlled by M.G. companies in attack over flat country, since the fire through gaps in the attacking infantry is not very effective and is dangerous. Heavy machine guns should be attached direct to front line infantry companies and used in a similar manner to light M.G's.

(2). *Electrification of Railways and National Defence.* The writer points out the danger of complete electrification of railways, which, if power stations were attacked from the air, might be brought to a standstill at a critical period. R.V.H.

HEERESTECHNIK.

(*April*, 1926). *Progress in Concrete-Making* (continued). By Lt.-Col. Augustin. A description of the Gravity system of laying concrete, invented in America, extensively used in the locks, &c. of the Panama Canal and lately more and more adopted in Germany. The concrete is made with enough water—10 to 14% of the total weight—to be capable

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of being poured into position. For this purpose a tower is necessary, whence the mixture is delivered through a system of traversable inclined gutters, to where it is required to be laid.

In Germany the process has been modified, in that, instead of hoisting the materials to the top of the tower already mixed, the mixing is done on top. This necessitates a stronger tower, owing to the weight of the mixing machine, but it saves the lifting of the water which is delivered at the top under its own pressure.

It has been found necessary to keep a constant check on the consistency of the mixture. This is done by taking samples at frequent intervals and measuring the lack or excess of water by a gauge, which shows to what extent the sample has subsided after the mould is removed.

The Influence of the Earth's Curvature and of Refraction on Determination of Heights for Artillery Purposes. By Survey Superintendent Lips. If h be the height of an object and d its distance from the observer, $h = d \tan \alpha$ is accurate enough for all distances up to 856 metres.

Between 856 metres and 2,000 metres a correction of E must be added to h, owing to the earth's curvature; and above 2,000 metres a correction of S must be subtracted for refraction.

Gauss worked out an equation combining these corrections, viz.

$$E—S = .87 \times \frac{d^2}{2r}$$

where r is the Earth's radius.

Hence in latitude 50° N. where $r = 6381$ km., E—S works out to 15 metres when $d = 14{,}858$ metres, or just over .1%.

Gas-shelters and Gas-protected Rooms (concluded), by Dr. Hanslian. Provision of ventilation with filters has been dealt with in the preceding article, but such means of protection are incapable of application to large buildings, on account of size and expense. It is none the less necessary to afford protection to the interior of large buildings against aerochemical attack. This article deals exclusively with this question. In blocks of Government offices, mobilization-centres, hospitals and institutions, central telephone exchanges and important factories it is insufficient to provide only places of refuge from gas. Such buildings must be protected so that work can be carried on without interruption. The first requisite for such protection is a chimney at least 160 feet high, *i.e.*, above the height of gas-bomb contamination, where fresh air can be sucked in by electric or other motors. It is also necessary to provide a system for distributing the fresh air in halls, passages and corridors throughout the block, and special ventilation outlets to allow the gas to be driven out.

When gas danger threatens, all windows and doors are shut, and the chimney, which must beforehand have been sequestrated from its normal use, is connected to the ventilation inlet and the ventilator is set running. The ventilator has a three-fold task. It has, by thinning the air, to overcome the resistance of the air-column in the chimney, it has to produce the necessary pressure to force the fresh air through the fresh air system of ducts throughout the building; and it has to maintain such an air-pressure in all the rooms as will force air to pass outwards through all

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cracks and crevices and thus prevent gas-contaminated air from entering.

A large building should have its air entirely replaceable in one hour. It has been calculated that 100,000 cubic metres of air can be supplied per hour through an inlet 1½ metres wide, by a 40 h.p. motor doing 260 r.p.m. It is obvious that no Government, let alone private firm, could face the cost of such an installation *ab initio*. It can only be carried out where chimneys of sufficient height are not only present, but available.

(*May*, 1926).—*Progress in Concrete-Making* (concluded), by Lt.-Col. Augustin. It is admitted that the crushing resistance of concrete made by the gravity system is reduced, by the addition of 10 to 12% of water, to only one-half that of ordinary concrete. This, however, does not constitute a drawback, since the crushing resistance of rammed concrete is quite unnecessarily high. As regards keying, all that is necessary is to lay the second layer within 4 to 5 hours of the first, the number of mixing machines and gutters being calculated to allow of this. While laying is in progress, a separation of stones from liquid is guarded against by keeping the fall below 2 metres.

A homogeneity, unattainable by other methods, is claimed for concrete laid by gravity, and the author considers this homogeneity of greater importance in determining the strength of concrete structures than the results of tensile strain and crushing obtained from samples. Illustrations are given of three different types of mixer.

The Physical Properties of Smoke for use in the Field, by Dr. G. Stampe. In the war smoke was used for concealment on all fronts both by the Germans and by their opponents, though only to a limited extent. That its further development is being worked at is proved by the appearance of an English manual "On the use of smoke." It is necessary to understand thoroughly the physical and chemical properties of smoke and mist to find out how best to use them in war. Both smoke and mist are names not of a kind of matter but of a state. What is characteristic of this state is the extraordinary fineness of distribution of the smoke or mist-forming substance in the air. The separate particles are mostly too small for their shape to be recognised even with the best microscopes. The separate particles of which cigarette smoke is composed vary in diameter from .4 to 6 millionths of an inch. The most usual distinction made in speaking of smoke and mist is that the former consists of solid particles, the latter of minute floating particles of moisture. The decision whether a cloud consists of one or of the other is often not easy to arrive at, and sometimes impossible. Thick fog often consists of both. The limits to mist are vapour, when it becomes invisible, with particles about 4 thousand-millionths of an inch in diameter, and rain, with particles about 4 thousandths of an inch, when the floating particles start to fall.

It is characteristic of mist that the separate particles even in perfectly still air have a spontaneous oscillatory motion, and that this motion is faster, depending on the smallness of the particle. Friction is so great that the rate of fall of the smallest particles is extremely slow. Thus with particles up to 4 ten-thousandths of an inch in diameter there is no reason to fear that a mist will become ineffective through sinking to the ground. Collision of particles causes an increase of size which is the principal reason why a mist settles.

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The minuteness of the particles makes it extremely difficult to remove mist from a stream of air by filtering. Generally the particles pass through the filter without any sieve-effect, but if the air passages in the filter are narrow and winding, as in textile materials and wadding, the particles are forced against the sides and stick there. Similarly the absorption filter of a gas-mask removes the particles of gas. It is true that the latter, being molecules, are much smaller than particles of mist, but this is compensated for by the far greater activity of the gas-molecules, which soon brings them against the walls of the passages.

As regards screening effect, all light-rays that strike a mist particle are lost to the eye, so that, although it takes to conceal one man from another 20 yards away, a pyramid, of which his outline is the base and the observer's eye the apex, containing 150 billion particles, the same effect would be attained with a screen, say 2ft. x 6ft. and the thickness of a single particle. This screening-effect is much less when the observer is looking with the light. Screening from the ground and screening from the air are thus two propositions, since an aeroplane-observer nearly always has the sun behind him, or at least well on the object.

As regards the effect of wind, a cloud of smoke or mist spreads out in the shape of a cone. With a steady wind and a ground surface not over-heated, as on summer evenings, it keeps to the ground.

"Industrial and Engineering Chemistry" gives the following formula from measurements by Walker,

h (height in metres reached by the cloud in t minutes)=
k (a factor depending on wind-velocity and wind-steadiness) x $t \times \sqrt{v}$ (v being wind-velocity in metres per second).

For steady winds (speed and direction)

$$h=13.5t\sqrt{v}$$

The next article will deal with the possibilities of the preparation of sufficient quantities of smoke in the field.

Extracts from the 1924-1925 *Yearly Report of the State Office for Survey.* Depicts a sad state of affairs, since with a 14% reduction of German territory, the surveying and cartographic personnel has been reduced to 57% of its pre-war strength. Further, there has been no fresh blood introduced into the Department for about 10 years, resulting in a menacing increase of age of the serving officials, 7% of whom are over 60, 23.3% between 50 and 60, 58.9% between 40 and 50, while the remaining 10.8% are between 30 and 40. The present diminished staff has not only to do almost as much as the State Office for Survey did before the war, but to attempt to fill the gaps due to cessation of work during the war and to the diminished performances of the unfavourable years immediately following the war.

10,000 trig. points, one-fifth of the whole number, have been lost. If this decay continues it will be impossible to restore some of them and new triangulations will be necessary. Between seven and eight hundred points should be restored yearly for the work of restoration to be completed in fifteen years. During the year under review the State Office for Survey was able to restore only 127 points of the missing 10,000. It is not difficult to agree with the author that something must certainly be done.

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(*June*, 1926). *Considerations on the Value, the Organization and the Tactical Employment of Tanks*, based upon an essay by Col. Invernizzi, Italian Tank Corps.

The author details the Tank units, parks, experimental branches, training battalions and schools possessed by Great Britain, France and the United States and considers that any doubts as to the effectiveness and value of the tank should be dispelled by the fact that the very practical nations inhabiting those countries are willing to spend millions on this weapon. Nevertheless he quotes, in order to combat in turn, several of these doubts :—

1. The next war will show radical changes both tactically and strategically, and the possibilities of aircraft and of chemical warfare are such that great expenditure on other weapons of uncertain capabilities should be guarded against.

2. The success of tanks in the Great War were only possible through surprise, effected by their being unfamiliar to the troops. This advantage will be lacking in future, and tanks will be unable to intervene in battle owing to the numerous and very effective anti-tank weapons

3. The tanks suffered enormous losses, even when the means of fighting them were insufficient both in quality and quantity.

4. Armour will be defeated by the armour-piercing projectile because the latter will force the former to increase until mobility has to be sacrificed.

5. Tanks can easily be defeated by obstacles, natural and artificial.

6. Tanks are useless to a country (Italy) which has only mountain frontiers.

Col. Invernizzi disposes of these objections, and then, always giving English and French ideas on the subject, he deals with tasks and characteristics, organization, training, co-operation with infantry, co-operation with other arms (containing a formidable list of tasks for engineers), use of tanks in defence and use in retirements.

The World-War, 1914-18. (E. S. Mittler & Son, Berlin). The German official history.

Vol. III, movements and fighting from 26th August to the 4th September, 1914.

Vol. IV, the battle of the Marne, from 5th to 9th September and a sketch of the German retreat from 9th to 15th September.

The reviewer lets himself go : " The battle of the Marne was the turning point of the war. How it happened that out of a victory which was clearly taking shape on the battle-field there could develop, through the failure of some few persons, a momentous retreat of the whole army, with its immense moral and political consequences, is a problem the clear recognition of which the present fate of the German people cannot prevent it from facing, which it owes to itself and to its future to know in every detail. The leaders who failed in those days are fully responsible to the people for their actions. To my mind still more responsible are those individuals who, in spite of doubts as to their suitability, proposed men for commands or left men in command, who either never had or no longer had the capacity for such responsible tasks."

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MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTELUNGEN.

(*May and June*, 1926).—*The Red Army of the Soviet Union*, by W. Kollosowsky, formerly Colonel of the Russian General Staff. The Red Army dates from 28th January, 1918, when a decree of the Soviet Government provided for the creation of an army on a voluntary basis. This attempt was a failure from the start, and in April of the same year Trotzky was obliged to introduce both universal service and the conscription of the technical personnel of the former Imperial Army. He further introduced the military hierarchy and strict centralization of command. The army based on these principles was used in the wars of 1918 to 1920, steadily improved in organization and took final form in 1924-25, when Frunse introduced certain changes, the most important of which was that the army was to be based upon the territorial militia, to which all cadres should be supplementary. The full title of the army is "The Red Workers and Peasants Army." It is most strictly centralized, in that the Soviet Republics have no right to dispose of the troops within their borders, a power which is vested in the People's Commissary for War, who is Commander-in-Chief of the Army, Navy and Air Force. The present holder of this office is Woroschillov. He is *ex-officio* President of the Council of the united Ministries of Army, Navy and Air Force, consisting of ten officials, of whom one only, Kameneff, is a professional soldier, having been a general staff officer in the Empire days. The remainder are of the working-class and their military experience dates from the Civil War.

The total strength of the army is given officially as 562,000, but it is believed to be over a million, and that the year's contingent amounts to 1,200,000, of which about 600,000 are taken to serve (250,000 in the standing army and 350,000 in the militia). Whether in the standing army or in the militia, the fighting formations are the Cavalry Division and the Rifle Division.

The Rifle Division consists of 3 Rifle Regiments of 3 Battalions each. A Rifle Regiment, corresponding thus to our Infantry Brigade, has a 6-gun battery, an Intelligence Company, a Signal Company, a Pioneer and Camouflage Detachment and a Chemical Warfare Detachment, besides commissariat and medical units. The Rifle Division amongst its Divisional Troops has a Signal detachment, a Pioneer company and an Engineer Train.

Corps Troops exist for every 3 Rifle Divisions, and include a battalion of Engineers, a battalion of Signals, a Tank detachment and a Kite Balloon detachment. In war each Corps also gets a flight of 8 aeroplanes. Amongst the special troops which exist outside the Division and Corps are troops for Railways, Camouflage service, Chemical Warfare, Pontoons, Electro-technics (including search-lights and electric-lighting), Signals (airline and wireless, also for carrier-pigeons and messenger-dogs), and for Meteorological Stations.

The Red Army has, in fact, been most thoroughly thought out and organized, but up to the present the technical troops have not been found in sufficient numbers. Especially in the Signal Service is the

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Red Army well provided with formations. This is a result of the lack of communication felt in the Civil War.

Against this provision of technical troops the provision of Divisions and Corps with Artillery is on so small a scale that the Red Army would certainly be handicapped against any of its possible opponents. The Soviet Union hopes to make good this deficiency by superiority in Cavalry of which it has the equivalent of 20 Divisions.

(*July-August*). *The Last Days before Königgrätz*, by Major-Gen Steinitz. The author has discovered in the War Archives a hitherto unknown document, the draft of a letter to the Emperor Francis Joseph written at Dubenetz, near Königinhof, on the 29th July, 1866, by Benedek the Commander-in-Chief of the Austrian Northern Army. Events moved so quickly after this draft was written that the letter was never sent. It is published now, not in order to criticise a report of the state of affairs composed in a black hour by a man in mental anguish, but in order to trace its connection with the development of the situation up to the decisive battle. Major-Gen. Steinitz attributes the catastrophe of Königgrätz not so much to external circumstances or to a lack of ability on Benedek's part as to the fact that he had lost confidence in himself and his staff and that his *moral* had gone. Support is lent to this view by the document now unearthed, and the author points the moral that, in spite of all progress, the human factor remains the most important in war, and that the decisive factor is the education and correct choice of the Commander.

Modern Manœuvres. By Lieut.-Field-Marshal Gerabek. In the years since the war ideas have cleared, or rather, as after former wars, they have become to a certain extent international. Evidence of this is borne by the fact that training in all countries shows much the same features, especially in the matter of manœuvres. All arms have to be trained to co-ordination. Such training, the author says, stands and falls with the faultless performance of the means of communication of all kinds. So in all modern exercises there is not only special weight laid upon the signal service, but skeleton exercises are held with signals only. For the benefit of those whose armies are small and consist mostly of cadres, so that manœuvres on a grand scale cannot be held, the author recommends substitutes, *e.g.*, a marked enemy and the full use of signals, even without the troops and staffs to which they belong, but he does not explain how, when other units are missing or consist only of cadres, the Signals are to be exempted from the general weakness and enabled to function at full strength.

The British Army Manœuvres, 1925. By Major-General Büttner. One of the most essential features of modern preparation for war is the striving to create, by mechanicalization, light and very mobile fighting forces. The Great War, with its rigid fronts, gave little opportunity for testing the uses and capabilities of such forces: it remains for manœuvres to do so; and this was the governing idea of the 1925 Manœuvres in the South of England. The points to be brought out were the effect of mechanicalized fighting forces and rapid tanks upon the conduct of war and of battle and—as far as peace-exercises permit—the establishing of principles as to their value; improvements in air-reconnaissance;

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improved co-operation between the troops and air-fighters. The directors of the exercise apparently expected the Western Army to make use of its superior mobility to defeat and drive back the advanced portions of the Eastern Army before the arrival of reinforcements.

On the first day, the attack by a mechanicalized infantry brigade was delayed 3½ hours owing to premature de-bussing. This could have been avoided by armoured car reconnaissance.

A skilful night retirement led to an attack being delivered upon positions already evacuated, a fact for which lack of air and ground reconnaissance were responsible and which can find only partial excuse in the bad weather which prevailed, and in the excellent concealment of the troops by day.

As regards the bussing of troops within striking distance of the enemy, this can only be done on the best roads and where both air and artillery are unquestionably superior. The new method of employing tanks, as tried on these manœuvres, is worth mentioning. Contrary to prevailing ideas, they were rarely used on either side to support infantry attacks. The new Vickers tanks were chiefly used in wide turning movements in conjunction with cavalry and mechanicalized infantry and artillery. This use finds its justification in the consideration that their greater speed, when working with the slow-moving infantry, cannot be utilized and is thus sacrificed. Also there prevails in English military circles the view that infantry, when their attack is supported by tanks, come to rely upon them and thus lose their initiative. The English, here differing from the French, use the rapid tanks for independent tasks, especially when, by reason of their speed or by using smoke to conceal them, they can effect surprise.

In addition to the foregoing, the rapid tanks can be used as a very mobile reserve for supporting threatened points, or for the clearing-up of localities offering obstinate resistance, also for co-operation with advanced or rear-guards, and for warding off hostile tank attacks. Other conclusions drawn from the manœuvres were that both cavalry and infantry must be equipped with effect've anti-tank weapons; also that ground won by the tanks cannot be held without the support of the other troops.

The Western Army included an Armoured Car Company consisting of 12 Rolls-Royce cars. It was used for reconnaissance and for raids against the enemy's flanks and rear. One detachment of 4 cars carried out a 200 mile expedition in 28 hours, seized important hostile operation-orders, fired on convoys, baggage-columns and aerodromes and sent back its reconnaissance report by two aeroplanes at the hour and place arranged. Armoured cars are most suitable for such tasks, given that roads are good and free from troops.

Also these manœuvres showed that the technical development of weapons and other aids, as well as the development of the methods of conducting war have been in uninterrupted progress since the Great War. The direction of this development is—in contrast to the progress during the Great War—more towards increasing the mobility of the weapons than their destructive effect. It strives to reconcile the differences of time and space and answers more to the requirements and needs of mobile warfare.

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Austria and her German sister-nation have by the Peace Treaties been checked in their development in military affairs. Indifference and inactivity in the face of the enormous progress of foreign armies would be a grave mistake. Attention to and study of all novelties will increase their knowledge and prepare them for future possibilities. There can be only one answer to the very real question "Material or Moral?" and that is "Both." Modern weapons are for the time prohibited: no peace-treaty can set bounds to moral improvement.

Aircraft Camouflage. By R. Burger, ex-flying officer. Aircraft are protectively coloured with three objects in view, viz., to guard against observation from the ground, to guard against observation from the sky, and for night-flying. They have thus to assimilate themselves to three different backgrounds, the day-sky, the ground and the night-sky. As regards the first of these, the war provided no solution of effective protective colouring with the sky as a background. No protective colouring can screen under such varying conditions the dirigible, the kite-balloon or the low-flying aeroplane. With an aeroplane at a great height it is a different matter. As the under-side is always in shade it can be lightened by bronze paint. This has the disadvantage that, when the 'plane is circling, a flash of light may betray it. The greatest success hitherto obtained has been by means of aiming at a transparent effect.

As regards the second object, all aircraft need dazzle-painting to conceal them when on the ground, and aeroplanes when flying low need it to conceal them from 'planes flying higher. From one aeroplane it is extremely difficult to spot another flying much lower, if the latter is painted to resemble the country. It would generally be seen first when crossing a road or water, but even then it is not easy to keep it in sight, unless the observer has a ground-shadow to help him, the existence of which in many cases alone makes observation possible.

As regards the third object, much can be done. Night-working dirigibles must be painted. The night-sky has its colour, and blue-black and/or violet should be chosen, and not too dark, since these colours must be able to absorb as much as possible of the airship's shadow.

Every kind of protection loses in value when the eye has got accustomed to it. This dictates two things, secrecy in peace and changes of colouring in war.

F.A.I.

JOURNAL OF THE SOCIETY OF ARMY HISTORICAL RESEARCH.

Vol. V., No. 21. July to September, 1926. Sheffield: Sir W. C. Leng & Co. 6*s.*

The most interesting features of this number are the "Articles of War, 1627," a "Memorial," by Sir Thomas Fairfax of his experiences in the Civil War, 1642-1644, and the usual notes, questions and replies. There is an attractive coloured print of a contemporary engraving of the battle of Dettingen.

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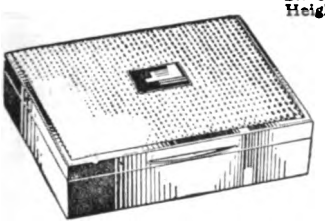

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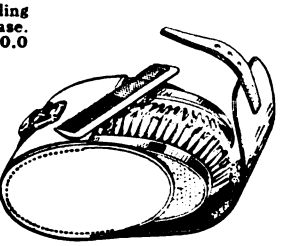

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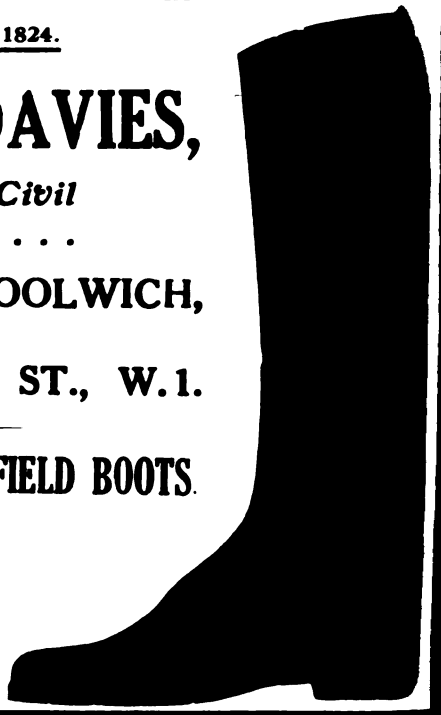

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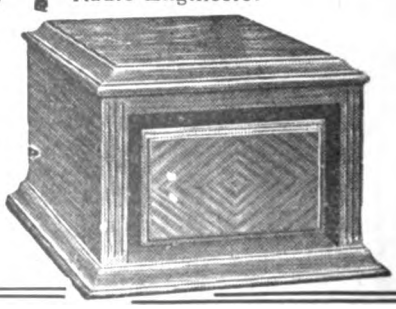

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